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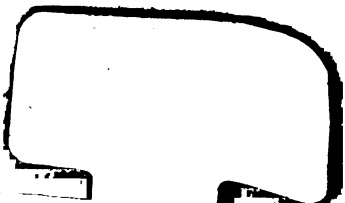

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METHODS IN MOSS STUDY

IN

TWELVE LESSONS

BY

CHARLES J. MAYNARD

WEST NEWTON MASS

C. J. MAYNARD

1905

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INTRODUCTION.

This book has grown out of practical lessons given by the author in moss study.

While the author herein endeavors to teach his pupils the close observation of specific and other characters necessary for the identification of species, his aims reach higher than this, and, as will be seen, the mere identification of species is considered subordinate to the study of the life history of each moss, its habits and its relation to its environment.

Without doubt mosses can be quite satisfactorily identified with a hand lens, but they cannot be thoroughly studied without a compound microscope. Many of the characters shown in the plates can be seen by using a half inch objective, but for some of them a higher power will be necessary.

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N I.

ALLIED FORMS. PL

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In preparing specimens for microscopic study the author has used water mounts under a cover slide, or when using a high power under thin sheets of mica. Sectioning leaves and other parts of the plants has been done with a sharp knife or scalpel. The specimen is cut wet while held by the nail of the forefinger.

The numbers which follow the names of objects in the explanations of plates indicate the number of diameters that the object is magnified, but this must be considered as approximate only. All marginal and other figures are considerably enlarged.

In preparing this little book I am greatly indebted for assistance and specimens to my friends, Mr. and Mrs. H. C. Dunham, Miss C. Lillian Gleason, and Messrs. Walter Gerritson and G. P. Annand.

C. J. M.

West Newton, Mass.,
April, 1905.

LESSON I.

RELATIONSHIP OF MOSSES TO ALLIED FORMS. PLANT STRUCTURE AND DEVELOPMENT.

In beginning the study of mosses it will be best for us to ascertain the position of these plants in the Vegetable Kingdom and learn something of their relationship to allied forms.

Plants may be divided into two quite sharply defined groups which we will term sections.

Section A; Flowering Plants (Phaenogams), more or less highly specialized; bearing flowers having pistils and stamens; the former named producing seeds which contain an embryo that has been fertilized by pollen born by the latter named.

Section B; Flowerless Plants (Cryptogams) , not as highly specialized; not bearing flowers, hence having no pistils nor stamens but reproducing by single celled germinating bodies called spores. See Plate I and accompanying explanation. For cut of pisitl, see Plate II Fig. 1 R; of a stamen, ib. I; of a spore, ib. H.

Flowerless Plants may be divided into more or less sharply defined groups of which the principal ones are given in the diagram on Plate I. The size of the groups is not indicated by the size of the figures, and the central, prominent position given to the group containing the mosses merely emphasizes their importance in connection with our present studies. See Plate I and its explanation.

We will now turn our attention to plant structure, and in order to lead up to mosses, begin our studies with a single celled plant. If we examine the bark on the shady side of

trees, stone walls, or the shingles of old buildings, we shall often find them coated with a green substance. This, when magnified sufficiently, will be found to consist of many spherical bodies, often clinging closely together in varying sized groups, but if placed in water and agitated most of these bodies will become separated. This is a single celled plant, an alga, known as protococcus, see Plate II, A.

When highly magnified with a compound microscope each of these spheres will be found to consist of an outer colorless wall, which is composed of cellulose, enclosing a colorless fluid mass, which is protoplasm. Within the protoplasm are a number of green grains often pressed closely together which are chlorophyll grains. The cellulose wall, composed largely of carbon, being more or less woody and tough, serves as a protection to its contents and as a medium of separation between them and the surrounding elements. The pro-

toplasm is composed of oxygen, noted for its susceptibility for combining with nearly all known elements, carbon, remarkable for its power of existing under two or more conditions, nitrogen noted for its inertness, and hydrogen with its great molecular activity; to these elements may be added sulphur and sometimes phosphate, both of which also exist under two or more conditions. To protoplasm is due all plant life. The function of the chlorophyll is when in the presence of sunlight to transform the gases and mineral matter absorbed by the plant into protoplasm.

Reproduction in the single celled protococcus takes place by division. In examining groups of protococci individual spheres will often be found in the act of dividing See Plate II, L. Within the sphere, but not always easy to detect, is a clear body known as the nucleus. Here division primarily begins; the nucleus first separates into two parts then

division extends across the entire cell. Hence each newly formed cell contains a portion of the nucleus. Occasionally the newly formed cells redivide before separating, see Plate II Fig. 1, B.

Sometimes what is known as endogenous division takes place within the cell walls and a number of very small cells are formed. These in time burst the cell wall and, being endowed with the power of movement, dart rapidly away, leaving the empty cell wall behind. On Plate II Fig. 1 F and E, will be found a cut of two of these motile forms, and at D, a cut of the emptied cell wall which I saw ruptured, allowing its contents to escape, on June 25, 1903. The specimen was obtained from a shingle which was on the north side of a building on my place. Two of these motile forms are said to meet, and become fused together, They then become surrounded by a single cell wall and ultimately produce the ordinary form

of protococcus. This process may be considered a kind of rudimentary fertilization.

The next form of plant life that we shall consider is also an alga where the cells have become permanently fastened together end to end as in the pond slimes, see Plate II, Fig. 1 G. It can readily be seen that it would be an advantage for a single celled alga living in moving water to thus join itself to other cells as then it would be less likely to be washed about by the water. Although growth takes place by the budding of new cells at the extremity of the plant, actual reproduction now no longer occurs by division, but by special bodies, known as spores, formed within the cells. These escape from the cell, and becoming elongated, bud new cells at their extremities, which in turn produce others, until a new plant is formed similar to the parent. Spore formation is preceded in many cases by what is known as conjugation. In some species of

pond slimes this is accomplished by a portion of some cell becoming swollen, forming a kind of elbow. See Plate II, Fig. 1, G. This comes in contact with another similarly developed elbow on another plant and protoplasmic matter is exchanged through the cell walls. This also must be regarded as a kind of fertilization

The next stage to consider will be where a plant would be placed under conditions where it would be necessary for it to produce more spores and which were better developed than in the pond slimes. In order to produce more, and better developed spores, a plant would have to be provided with more energy than one which did not have as much to accomplish. Energy is a product of food and food is absorbed by cellular surface, hence a larger cellular surface would be necessay if more energy were required. Under many conditions of environment it would be disadvantageous

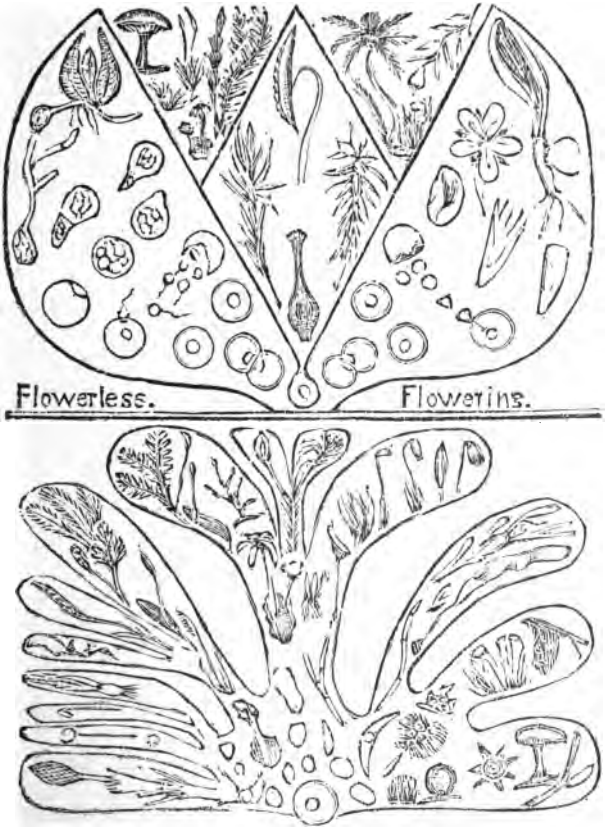
EXPLANATION OF PLATE I.

The upper diagram illustrates an ideal ancestoral development of Flowering and Flowerless Plants.

Both began with the single cell stage, propagating by division as in the Protococcus. In Flowerless Plants a specialized single cell produced numerous small cells by endogenous division. These being motile sought a large single cell and fusing with it furnished additional elements which caused important changes to occur in the cell which it joined. As illustrated in mosses, the modified cell assumed chlorophyll, and gradually elongating, produced protonema by budding. This protonema by gradual change in certain portions, budded off cells that accumulating by budding assumed the form of leaves which in turn accumulated, and a moss plant was the ultimate result. In order to accomodate the increase of the fertilizing and fertilized cells special receptacles became evolved, the perigonium and perichaetium, illustrated on the right and left of the diamond shaped figure in the center.

In Flowering Plants development proceeded in parallel lines with Flowerless until after the fusing of the two cells. Then the motile cells became more highly specialized in some particulars, but lost the power of movement, and becoming pollen grains, depended upon some foreign agency to convey them to the cell to be fertilized; the opposite, quiescent cell, also became more specialized, and became a germ, or embryo, from which the future plant was produced without the intervention of any secondary growth. Special receptacles were also evolved for the accomodation of both kinds of cells; the stamen and pistil, see central diamond, upper an clower figure. In order to effect the union of the two cells through foreign agencies, ac-

PLATE I.



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cessory parts become grouped about the stamen and pistil; the floral envelopes, and they with the pistilsand stamens constituted the perfect flower.

To the right of the diamond above are typical Flowering and to the left typical Flowerless Plants.

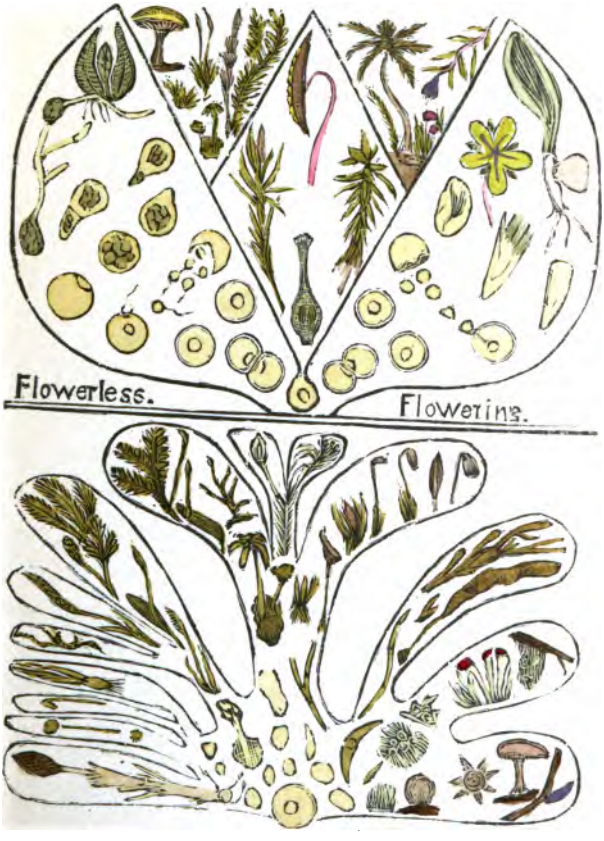
The lower diagram illustrates the position of the mosses in the Vegetable Kingdom. On the right is a lobe divided into thee parts, the upper of which represents the algae, from which in turn through the lower single celled forms have become evolved lichens and fungi. In the center are the Cellular Cryptogams with the mosses on the right and the liverworts on the left while between them are the sphagnums and the schizocarps; all of this group are closely connected together. Then come the ferns, lycopodiums, selaginellas, quillworts, marsiliae, azollas, and horsetails, but the order of relationship of the last four mentioned is uncertain. All begin with the single cell, prominent in the center of the base.

for plants to add cell after cell end to end, but far more advantageous to add them side by side, thus producing a flat surface a single cell deep. See Plate II, Fig. 1, J. This is the way in which typical moss leaves are formed.

With the production of leaves came the necessity of some structure for their support, hence the stem, with which most mosses are provided, become evolved. To support the growth of stem and fruit together required more energy than the leaf cells growing in air or water could furnish, hence subterranean branches of the stem were projected into the the earth there to absorb not only moisture but also mineral matter from the soil. These root like projections are known as rhizoids.

Abundant and more highly specialized spores would require special receptacles for their development and growth so arranged that upon the maturity of the spores they could be distributed in such a manner as would be ad-

PLATE I.



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vantageous to the future development of the plants that were produced from them. Hence we find the capsules of mosses (see Plate II, Fig. 2, K and Q,) often elevated upon stems, protected by a special covering when growing (see the calyptera or hood ib. L and R). The spores are in many cases retained within the capsule, even after the calyptera has been shed, by a lid or operculum, see ib. J and Q. After the operculum has been thrown off the spores are still retained and gradually distributed at favorable moments by a greatly varying device known as the peristome, see ib. D and F.

Fertilization is accomplished in the mosses by single celled organisms known as antherozoids, developed in special receptacles, the antheridia, see ib. O. These often grow upon specialized stems and are protected by differentiated leaves, known as bracts, see ib. N and P. Clustered about the base of the anthreidia are slender, usually colorless, joint-

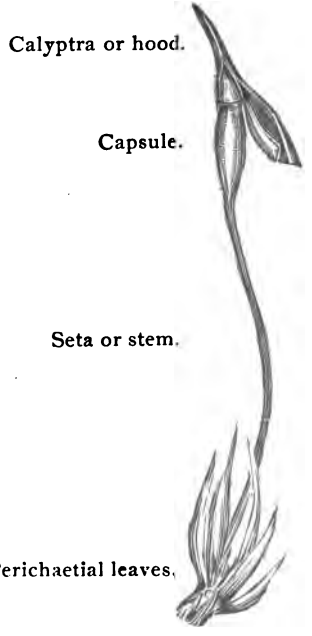
ed organisms that recall the segmented pond slimes. They are called paraphyses, see ib. N and Fig. 1, K. Although these are probably rudimentary leaves, their function is evidently to assist in protecting the antheridea.

During rainy weather the motile antherozoids, freed by the rupture of the antheridea, swim to the young capsule, now known as the archegonium, and penetrating it, fertilize the developing spore cells.

The ripe spores, when placed under favorable conditions, begin to change by the development of chlorophyll, then gradually elongate on one portion (see ib. I), which in time receives a few grains of chlorophyll (see ib. II); shortly after this the elongated portion separates as a distinct cell, See ib. III. This cell elongates and buds out other cells, much as do the pond slimes. In time, portions of this protonema, as it is called, become enlarged and crowded with chlorophyll grains. From

these enlarged portions cells are budded off that in turn produce other cells until leaves are formed, and finally a little moss plant is developed.

In the following lessons we shall return to all of the points mentioned regarding mosses under species where they can be most favorably studied.



Spore-bearing portion of a Moss Plant Ditrichum tortile, enlarged.

LESSON II.

CLASSIFICATION. THE FAMILY OF HAIR-CAPPED MOSSES.

For convenience in study, all objects in the great world of nature have been arranged in groups, in other words they have been classified according to the opinions of students who have become familiar with them.

Taking plants as an illustration, we have seen that they have all sprung from one lowly beginning; the single cell, and that advancement from this point to more highly specialized forms has been gradual. As we have to look far back in the history of our globe to find the first traces of vegetable life, and as many changes have taken place on its surface since then, it becomes evident, that although some forms

of plant life may have persisted until the present time without special change, many other forms have been lost.

In compliance to the laws of evolution, certain groups among plants have become established while the links of the narrow chain by which they were connected with the forms from which they originated were in existance. While other groups which now appear widely separated from any closely allied forms, have become thus isolated only through the complete extinction of all the connecting links. Hence it follows, in many cases, that our ideas of the classification of plants is due rather to our ignorance of the forms that have been in existance in the past than to our knowledge of those we now find.

We must, then, distinctly understand in the beginning that the classification of plants is the expression of opinions of students who have given the subject more or less careful at-

tention, but which may differ from those of others who have given the matter equal attention. I will hasten to add, however, for the benefit of those who are contemplating beginning plant study, that botanists of today are quite well agreed as to the classification of the higher groups, it being among the lower, like genera and species (to be explained presently), where we find the most divergence of opinion at present. Fortunately the characters by which these lower forms are separated, especially in mosses, are usually easily studied, and the earnest student soon becomes acquainted with the facts that form the base of any mooted questions.

As a sequel to the foregoing, I would say to the student, who is beginning the study of mosses, as I would say to one who is beginning the study of any department in nature, take nothing for granted that has been said by others; the student should use their instruc-

tions only to guide him in his own studies; he should early acquire the habit of investigating everything for himself. With the facts within his grasp, the careful student who has learned to think for himself, is in a positon where he can judge of the correctness of any expressed opinion regarding these facts.

We will now turn our attention to the grouping of mosses and to the terms that are applied to these groups. In our last lesson we found that mosses were placed among flowerless plants which formed a section of the great vegetable kingdom. By referring to the lower diagram on Plate I, it will be seen that mosses form one of the principal divisions in the section of flowerless plants; the Cellular Cryptogams. This division we will call a branch.

Again referring to the diagram, it will be seen that this branch is subdivided into four minor groups, namely, mosses, sphagnums,

schizocarps, and liverworts, each of which constitutes what we may call an order.

Mosses, then, are considered an order, and further divided into families, one of which we shall describe in our present lesson.

Among the most common and easiest recognized of the mosses are those which resemble little pines or junipers, and which occur in old fields, in bogs, and in open woodlands. Many of them may be further known by their abundant capsules which are covered with hairy calyptera (see Plate I, Fig. 1, G and R) On account of this Robinson Crusoe cap they are called hair-cap mosses. There are several kinds of these hair-caps, all of which have certain well defined characters in common by which they show their relationship. On account of this very obvious relationship the hair-caps are placed in a group by themselves, a family, explained on the next page.

Family. HAIR-CAPS. Polytrichaceae.

I have stated on page 10 that typical moss leaves are made up of cells placed side by side, one deep. Now if we examine the leaf of the largest and most common of the hair-caps with a compound microscope, using a low power, we shall find that while this is is true regarding the cells of the part that constitutes the original leaf, there are lamellae like projections placed side by side and extending across the entire upper surface of the leaf. See Plate II, Fig. 2, M. A section of this leaf is given at ib. G, where the lamellae may be more clearly seen. These lamellae, developed to a greater or less extent, occur on the leaves of all the hair-caps.

If we remove the hairy calyptera of the common hair-cap, gathered in June, we shall we shall find the lid, or operculum, beneath it.

See ib. Q, where the operculum is shown in a side view, in place, and J where it is shown separate from above. Removing the operculum, the peristome is exposed. This is made up of sixty-four short teeth, rounded at the tip (see ib D and F). The interspace within the the encircling teeth is composed of a flat, roughened surface, known as the epiphragm. See ib. D.

The next point to be observed is the peregonium, or antherozoid producing portion of the moss plant. This is easily found and is known by the rosette of bracts, the inner of which are often highly colored. See ib. P and N.

All of the characters given, but varying somewhat, are found in all of the hair-caps, and consequently constitute what are known as the family characters. Following is a summary of these, to which is added the function of each.

Summary of Family Characters.

Leaves, furnished with longitudinal lamellae; function, furnishing additional nutriment to abundantly fruiting mosses.

Peristome, with many short, rounded teeth, connected with an epiphragm; function of both, regulation of spore distribution; see further explanation in Lesson III.

Peregonium born on a separate plant, with the bracts arranged rosette-like; function, the protection of the antheridea.

LESSON III.

THE TRUE HAIRCAPS AND THE BEARDED HAIRCAPS.

Not all of the haircaps are exactly alike, some do not even have the hairy calyptera, and there are other differences between them, but, if we study the different kinds with care we shall find that some have characters, aside from those given under the family, that are shared by others; in short, we shall find that the family may be further divided into groups, which are called genera (plural of genus).

Genus. TRUE HAIR-CAPS. Polytrichum.

In the first group or genus that we shall consider is placed the common hair-cap. This moss, as we have seen, has the calyptera hairy (see Plate II, L and R), the capsule angled

(see ib. H) and the leaves long and narrow, standing out from the stem when wet, but clasp, ing it when dry. Three other of our common hair-cap mosses possess similar characters. On account of this, these with the common hair-cap are placed in a genus by themselves. This genus is called Polytrichum, and contains the true hair-caps.

We will now examine the various kinds of mosses in this genus, each of which is called a species.

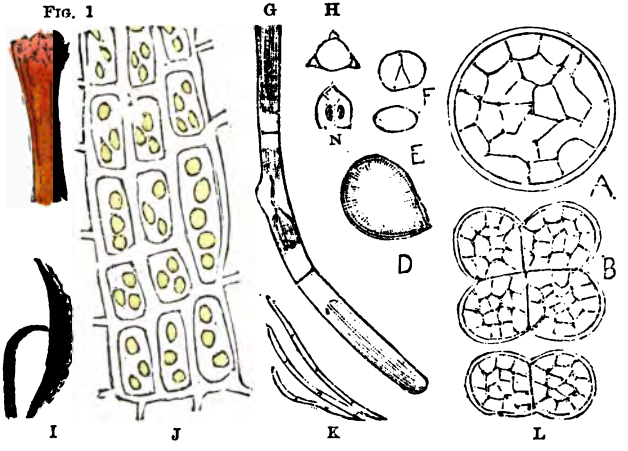
The first that we shall study will be the common hair-cap, P. commune. Again examining the leaves of this species we find that the margin for the greater portion of the terminal length is serrated. See Plate II, Fig 2, M. The calyptera covers the entire capsule and even clasps the stem. The capsule is square in section (see ib H) and when dry bends downward below right angles with the stem (see Plate III, B).

EXPLANATION OF PLATE II.

Fig. 1 :- A, Protococcus cell, 1000; B and L, same dividing. F and E, motile form of same; D, ruptured wall of same, 500. H, pollen grain of feverwort, 500. N, ovary of flowering plant, 200; G, pond slime, 50; K, paraphyses of Webera sessilis, 50; J, leaf cells of Bartramia pomiformis, 500; L, anther, and figure above it, pistil of a species of lily, 10.

Fig 2 :- M, leaf of Polytrichum commune, 10; G, section of same, 50; H, pollen of same, 1000; K, capsule, L, with calyptera of same, life size; Q and R, same, 10; J, operculum of same 10; D, peristome of same, 20; F, teeth of peristome, 50; H, (lower Fig.) section of capsule of same. 10; N, perigonium of Polytrichum piliferum, 50; P, same from above, life size; O, antheridia of same, 250; V, protonema and young plant of Webera sessilis; I, II, III, developing spore of a species of Brachythecium, 1000.

PLATE II.



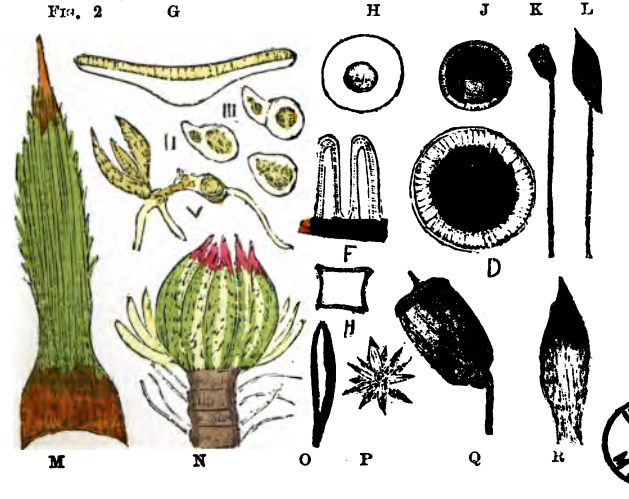


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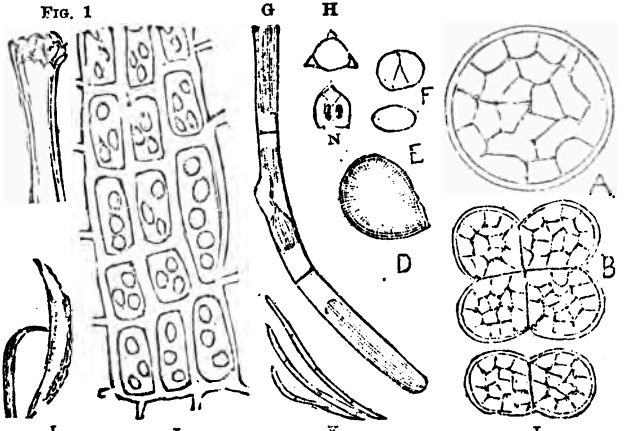
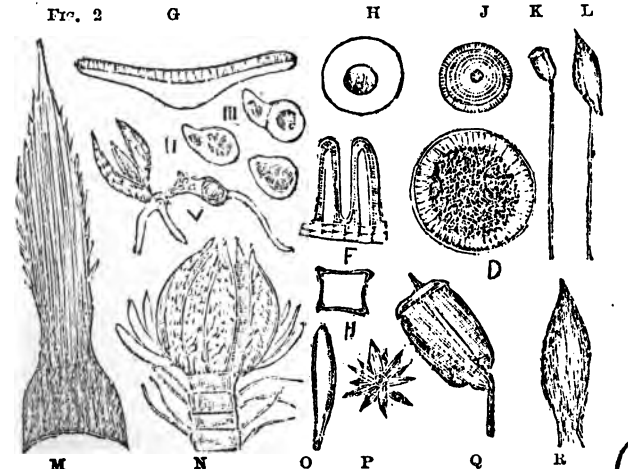
PLATE II.





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The common hair-cap is found in old fields and meadows and often in bogs, where the stems sometimes grow a foot long, but the average height is not over four inches. Its color is greenish yellow. The common hair-cap begins to develop its capsules in late summer, or rather they can be seen protruding their slender, orange-colored calypteras above the green perichaetial leaves, but the capsules do not ripen their spores until the following July hence the need of the hairy calyptera in this and others of the same genus for protection to the capsule in winter.

If we search in open woodlands, especially on ridges, we shall find a moss that at first sight resembles the common hair-cap, but close examination will show us that although the leaves are serrated, they are more pointed and more slender than in the common hair cap. See Plate III, E. Next we see that the calypteras do not entirely cover the capsules, but

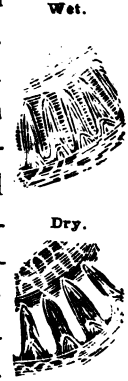
leave the base exposed. See ib. H and I. The capsule is not as box-shaped as in the last but narrows gradually as it approaches the stem, and when dry is not bent below right angles with the stem. See ib. A and C. Its color is also of a paler brown. This species is the wood hair-cap, P. ohioense.

The wood hair-cap occurs, as I have said, in open woodlands on oak ridges, where I have always found it growing rather scatteringly in small patches. The stems of the capsules are rather longer than in our other hair-caps. The color of the moss is rather light green. The spores are shed a little later than are those of the common hair-cap.

This form of moss was probably evolved from the common hair-cap on account of the change in environment. A moss accustomed to growing in open places gradually learning to grow in the shades of woodlands would be less luxuriant than the parent form, while the

stems would have to be of a greater length to raise their capsules above the fallen leaves of the previous year.

I will now explain the method by which the hair-cap mosses discharge their spores. Referring to Plate II, Fig. 2, D and F, it will be seen that the short teeth meet the epiphragm from which a toothlike projection extends between them; this is best seen in the marginal cuts. In damp weather both the teeth and epiphragm expand so that there is no orifice whatever between the teeth, but in dry weather both shrink and then there is an orifice between the teeth through which the spores escape, but most abundantly when the capsules are shaken by the wind, and this is the time which is most the favorable for their distribution.



Peristome of the wood hair cap.

Keeping in mind the above given method of distribution it can be readily understood why, in order to discharge the last spores, the

box-like capsules of the common hair-cap are bent downward until the orifice is directly below. It can also be seen that on account of the oblique angle from the peristome to the bottom of the capsule of the wood hair-cap all of the spores would slide out even if the capsule were bent no lower than at right angles with the stem.

We will now examine another species of the genus. If we pay particular attention to the patches of hair-cap mosses that we pass, we shall find that some of them are made up of moss plants that have leaves of a different shade of green from those of the last two species given, and instead of being yellowish, they are of a decided bluish or sagey green. Upon magnifying these leaves it will be seen that much of this peculiar shade of green is is due to the fact the margins of the leaves, which are folded over on either side so as to nearly cover the entire upper surface of the

leaf, are so excedingly thin as to be translucent. Hence in looking at the surface of the lamellae we must look through this semi-transparent covering, and this gives the green beneath a sagey or glaucus shade. See Plate III, G. This is the juniper hair-cap, P. juniperinum. The only portion of the leaf that is serrated is the extreme tip, and this is prolonged into a kind of an awn, and if we magnify it considerably we shall see that the apparent serrations are really spines that extend all around the awn. See ib., F. The awn is orange in color.

The capsule of the juniper hair-cap is wholly covered by the calyptera, but this is much more pointed than in the common hair-cap. The ripe capsule, although four sided, is much compressed, while the lateral angles form quite conspicuous wings. See marginal cuts. On account of this compression the spores are discharged without the capsules be-

Capsule and its section of juniper hair-cap.

ing inclined at more than right angles with the stem.

Although the juniper hair-cap may be found mingled with the common, which it resembles in size, it more often grows in dryer places, and may be found at the bases of dry hills or in open places along woodland paths. It fruits about the same time as the common hair-cap.

A smaller species of hair-cap is found in dry, gravely places, or in depressions of rocks where a little soil has accumulated. This is the awned hair-cap, P. piliferum, and it also has the margins of the leaves folded over (see Plate III, O), but it may be known at once by the long, transparent awns which are provided with rather scattering lateral spines (see ib., N). These awns may be seen with the unaided eye when the moss is held against the light. The calytera is of much the same form as in the juniper hair-cap, see margin,

Calyptera of awned hair-cap.

and the capsules, although smaller, are much the same form as in that species.

There are other species and sub-species of this genus but none of them are very common and thus need not enter into our studies at present.

Genus. BEARDED HAIR-CAPS. Pogonatum.

If we search on soil that has been disturbed within a few months, we may find a moss growing on it that nearly resembles those we have already studied. A close examination, however, will show that, although it has a hairy cap, it differs from the true hair-caps in one particular; removing the cap we find that the capsule is not angular, but cylindrical. See Plate III, V, and a section of same at X.

Our most common species in this genus is the one now under consideration, the short-stemmed bearded hair-cap. This moss has

very few leaves, and what few there are will be found twisted about the base of the capsule stems. The leaves have wide, sheathing bases, almost wholly without chlorophyll, and although the lamellae extend down into this portion of the leaf, it is mostly confined to the narrow, curved, projecting part, see ib. P and Z. The cells of the lamellae are not as regular as they are in the true hair-caps, see ib., R and T. Although I have found the capsules of the short-stemmed hair-cap growing as thickly as in any species of true hair-caps, they are more often scattered over a wide surface, with the interspaces between covered with green, felt-like protonema, that is remarkable in being furnished with chlorophyll for its entire length, and for being permanent; that is, it does not disappear as does the protonema in most mosses after producing the young plant. It must largely take the place of leaves in supplying nutriment to

the capsules, and may be an example of the persistence of a primitive method of moss growth. This species ripens its fruit about Boston in the spring.

EXPLANATION OF PLATE III.

A, capsule of P. ohioense; C, same enlarged; H, calyptera of same lite size; I, same enlarged; K, female plant showing developing capsule, life size; J, calyptera of young plant, 2; D, male plant of same showing three separate peregoniums of different years growing one above the other; E, leaf of same; B, capsule of P. commune, 1; C, leaf of P. juniperinum, 10; F, tip of same, 50; O, leaf of P. piliferum, 10; N, tip of same, 50, VI and U, sections of leaf of same, 50; M, Young capsule of of same, 50; II plant of Poponatum brevicaule, life size; III, calyptera of same, 10; Z, leaf of same, side view, 10; P, same, 50; R and T, section through leaf, 100; V, capsule of same, 10; X, section through same, 10; W, spore of same, 500.

PLATE III.

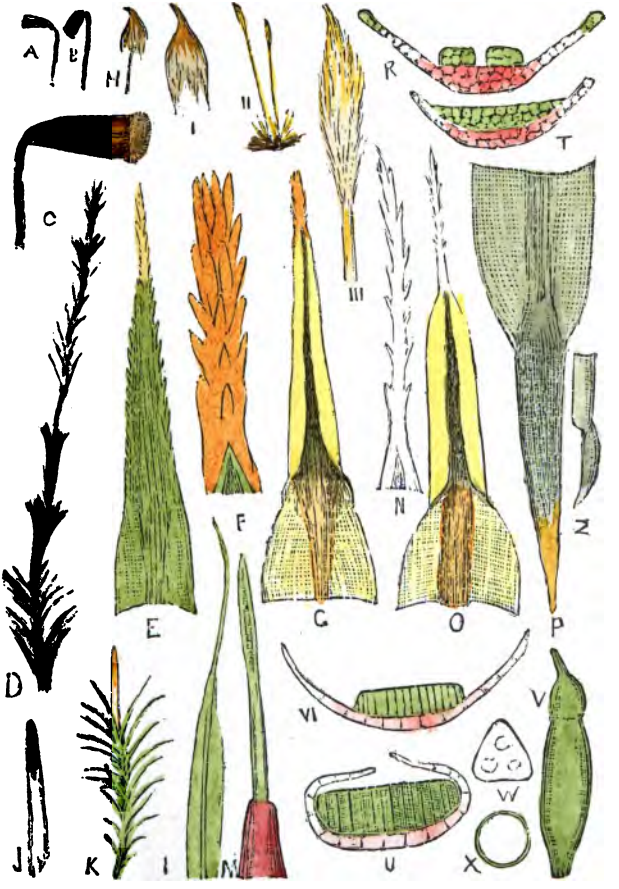


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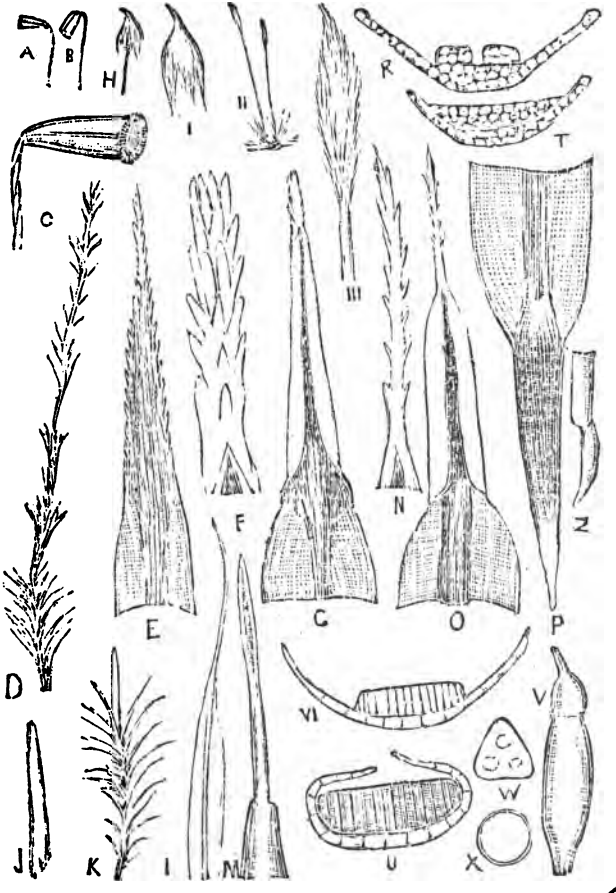
PLATE III.



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LESSON IV.

THE BEAKED HAIR-CAPS. THE CORD MOSS.

Genus. BEAKED HAIR-CAPS. Catharinea.

Mosses which belong to this genus grow in soil that is rich enough and moist enough to support ordinary vegetation. At first sight they appear to resemble the hair-caps that we have already considered very little, yet if we examine the leaves we shall find they are all furnished with lamellae similar to those in other hair-caps, but these are confined to the middle of the leaves See Plate IV, C and L. Although the operculum is beaked (see ib., H), the peristome is made up of short, rounded teeth and an epiphragm similar to those we have found in other hair-caps. See ib., A and

N. The calyptera differs from that of other genera in this family in having the tip only provided with anything that approaches a resemblance to hairs. When the tip of the calyptera is magnified considerably it will be found to be covered with short outgrowths, mere apologies for the hairs once worn by its ancestors, see ib., I. The leaves do not clasp the stem when dry but become crisped.

Two species of this genus are quite common with us. The first that we shall consider is the narrow-leaved hair-cap, C angustata, which is found in many places, along the base of stone walls, beside old buildings, on the margins of woodlands, or even on lawns, growing among the grass. The leaves are provided with six or more lamellae that occupy at least more than a quarter part of the upper surface. See ib., C and a section at R. The lamellae are composed of from six to eight rows of cells See ib., T. The back of the leaf is furnished

with spines that are arranged in more or less regular rows on the terminal half. The capsules, which are abundant, are rather strongly curved (see ib. E and K), and the calyptera is inclined at right angles. Male plants have the perigonium provided with bracts which are arranged in the same rosette-like manner as in the true hair-caps. See margin.

The second species which we shall consider is the wavy-leafed hair-cap, C. undulata. This differs from the narrow-leaved in the plant being of a larger size (see ib., M), and in the leaf being wavy and furnished with four or five lamellae, which occupy less than a quarter of the surface (see ib., L and O) and which are only three or four cells deep. See ib., P. The capsules, which are not abundant, are quite similar in form to those of the last species, but are larger. The plant is found in quite moist places. In both species the color of the leaves is a lively green, and the capsules

Male plent of C. angustata.

with their stems are reddish-brown, darkening with age to a mahogany color. Both species ripen their spores in autumn.

In reviewing the facts which we have gathered in our studies of the hair caps, and reasoning about them we find that in its scarcity of leaves and in the permanent protonema, the short-stemmed hair-cap is probably the most primitive form. This is, however, a hardy species for it grows in rather exposed places. On this account the most favorable time for it to distribute its spores is in spring, hence it retains them in its capsules all winter, but protects them with a hairy calyptera.

This moss has given rise on one hand to other more highly specialized species which still retain the cylindrical capsule, and also to a still more highly developed group; the true hair-caps, which by their extended lamellae are enabled to furnish nutriment to abundant fruit.

From the bearded hair-caps on the other hand, have probably sprung the beaked hair-caps; less hardy species which mature their spores in early autumn, hence do not need the hairy calyptera to protect them. As these species fruit less abundantly they do not need extended lamellae for extra nutrition, but the scarcity of lamellae has been partly counterbalanced by the chlorophyllose surface of the entire leaf.

In the genera themselves we find that evolution of portions of the plants have occurred to meet the changes in environment, and this evolution has produced what we call species

Thus in the true hair-caps we find that the most highly specialized species, the common hair-cap, lives in the richest soil, produces the most luxuriant plant growth, and fruits the most abundantly. The wood hair cap growing in the shade, has less foliage and less fruit,

but has elongated its capsule stems as already mentioned.

The juniper hair cap, growing in dry places, has protected its lamellae by folding the extended margins of its leaves over them, thus retaining the moisture longer than if they were exposed, while this nearly transparent covering readily admits the sunlight, but this plant fruits rather less abundantly than does the common hair-cap.

The awned hair-cap grows in even dryer places, hence having less energy to expend has reduced its leaf surface considerably, but retains a vestige of their former length in the extended awn. It protects its lamellae in a similar manner as does the juniper, but its fruit is not as abundant.

All of the true hair-caps fold their leaves close to their stems in dry weather to retain the moisture as long as possible on the lamellae.

CORD MOSS, Funaria hygrometrica.

This is a common moss found growing on ashes: and easily recognized by the bowed, wrinkled capsules (see ib. U and II) which with their stems are bright reddish brown in color. Although not often over three fourths of an inch in height, I have seen them twice this. As a rule it is not a luxuriant growing species, but I know of a portion of a drained meadow of half an acre in extent where a peat bed has been burned out, that is red with the capsules, which grow so thickly together that the gray ashes beneath cannot be seen.

The leaves of this species are very small, but now instead of lamellae on the upper surface we find a raised portion which extends through the middle of the leaf, known as the costa. (See ib. III). As may be readily understood this assists to support the leaf.

Removing the flattened operculum (see ib., VI) we find that the teeth of the peristome are quite different from those of the hair-caps for they are long and slender and are crossed at regular intervals by bars or articulations, which protrude beyond the teeth near their tips. See ib. IV. The teeth are reddish-brown and the articulations are of a deeper shade. The tips of the teeth are connected together by a cobweb-like structure which is a vestige of the epiphragm. See ib., VII. Between the sixteen teeth, which all have their tips turned to the right, are long, slender, transparent processes, known as the cilia. See ib., IV. These probably represent a portion of the changed epiphragm. The whole of this peristome is only another devise for spore distribution and illustrates the change of an organism to meet the needs of the plant.

EXPLANATION OF PLATE IV.

Catharinea angustata :- A, peristome, 20; B, growing capsule, 20; C, leaf, 10; G, back of same; D, growing calyptera, 20; F, tip of same, 40; E, plant, 1; H, operculum, 10; I, tip of mature calyptera, 50; J, spore, 500; K. capsule, 10; N, teeth; R, leaf section, 50; T, cells of one lamella, 40

C. undulata :- M, plant, 1; L, leaf, 10; O, leaf section, 20; P, cells of one lamella, 50.

Funaria hygrometrica :- U, fruiting plant, 1; V, growing calyptera, 10; W, growing capsule, 50; II, capsule, 10; III, leaf, 10; IV, tooth of peristome and cilia, 100; VI. Operculum, 20; VII. tip of a tooth and vestige of epiphragm; X. spore, dry; Y. same wet, both, 500.

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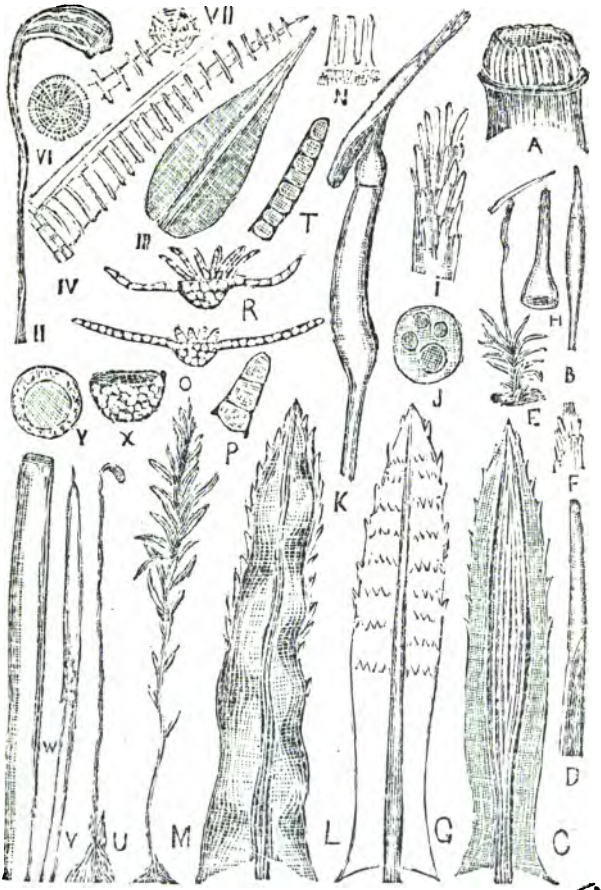
PLATE IV



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LESSON V.

THE SESSILE MOSS. THE BROOM MOSSES.

The Sessile Moss, Webera sessilis.

If we search on moist, shady banks upon which little vegetation grows, we may find a deep green velvety moss with short pale brown capsules that all face toward the light. These capsules are often crowded thickly together and this habit of turning toward the light gives them a peculiarly animated appearance almost as if they were conscious of the act, and who shall say that they are not? This is the sessile moss (see Plate V, A). The one sided capsules have the teeth of the peristome attached together by a membrane. See ib., E and H. The male plant (see ib., B) and the

female (see ib. C) are surrounded with leaves that not only have long slender awns but which have their margins split up into segments. These segments are provided with elongated cells which are without chlorophyll, and each segment extends to the base of the leaf. Hence the outer portion of the leaf is made up wholly of these hyaline cells, thus the only portion that contains chlorophyll is the costa. See ib., I. Now if we examine the growing capsule we shall find that it is protected by many paraphyses-like growths that in their segmented, hyaline cells and elongated form, closely resemble the outer segments of the leaves. These paraphyses are greatly variable in size and some are nearly as long as the leaves, see page 53. In studying them one cannot avoid being impressed with the idea that they were the origin of the leaves.

The vegetative leaves are rounded at the tip and the margins are provided with spher-

ical cholorophpllose cells. See page 53. Although this interesting moss has received considerable attention, much of its true history probably remains to be written.

I have found the sessile moss on banks by roadsides and along woodland paths and also on small mounds in woodlands. It fruits in early summer.

Genus. BROOM MOSSES. Dicranum.

Members of this genus are among the most conspicuous of our woodland mosses, for they grow in thick mats and some of them are very bright green in color. There are several species, but we shall consider three only. All of these resemble one another in having the leaves turned in one direction or secund, as if they had been blown that way by the wind. See ib., V, Z, and N. Examining the leaves we find that they are more or less tubular, that is the margins are rolled

in (see ib., T, R, and P), and their cells are elongated. See ib., X, Y, and II. The operculum is beaked. See ib., VII, XI, and XIII. The teeth of the peristome are sixteen in number, red in color, articulated, with their tips divided into two or three parts. See ib., IX, XII, and XV. These constitute the generic resemblances or characters.

The common broom moss, D. scoparium, is the first one that we shall consider. Now while keeping in mind generic resemblances, we must look for specific differences. The color of this species is yellowish-green; the plants are taller than in the other two species (see ib., V); the leaves are tubular for a greater portion of their length (see ib., P); the tips are decidedly serrate on margins and back (see ib., IV); their cells are irregular in form and are provided with elongated portions that would come in contact with one another were it not for the intervening cell wall

(see ib., II); the capsules are bowed over See ib. VI and VIII.

This moss is very common in moist places, but while the vegetative forms are very abundant, the fruit is not always to be found. The capsules ripen their spores in early autumn.

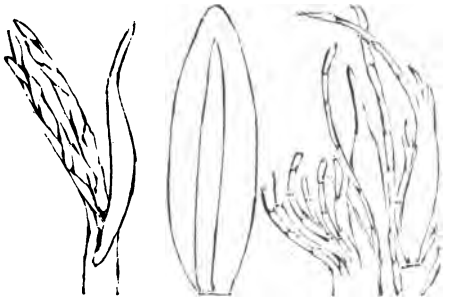
The whip moss, D. flagellare, is also a swamp living species, but it is rather less common than the last. It is about the same color, but the plants are shorter (see ib., Z); leaves, short-pointed, tubular for a little more than one half the terminal length (see ib., T) and serrated at the extreme tip only, see ib., W; cells, irregularly rhomboidal, see ib., X; capsule erect and narrow, with the operculum very long-beaked, see ib., XIII; the teeth are long, see ib., XIV and XV.

This moss takes its name from the slender, whip-like branchlets that are sometimes found growing from the stems among the leaves.

The third species is the fulvous moss, D. fulvum, and may be found growing on rocks in damp woods. Color, rather brownish-green; plants, short, see ib. VI. Capsules erect, thickened in the middle, with the operculum short-beaked, see ib., XI; teeth, short, see ib., XII; leaves, long and narrow, tubular for the terminal two-thirds, see ib. R, and with the tip distinctly serrated, see ib., III; cells, decidedly rhomboidal, see ib., Y. This and the last species fruit in mid-autumn.

Although the changes resulting in specific characters in members of this genus are of course due to environment, we will not now consider the reason for these changes, the present lesson having been given to further train the observation of pupils, and teach them to distinguish the differences between generic resemblances and specific differences, and to select the most important of the latter named. Also to show the probable origin of leaves in

at least one species of moss through the gradual devlopment of the paraphyses.



A, flagella of the whip moss; B, leaf of the sessile moss; C, paraphyses of the same.

EXPLANATION

Webera sessilis[illegible] plant, 2; D. [illegible] growing cal[illegible]

Dicranum [illegible] capsule, 10; [illegible] wet, J, same [illegible]

D. fulvum [illegible] leaf cells, 100 [illegible] I, same dry, [illegible]

D. flagell[illegible] cells, 100; XII[illegible] 50.

PLATE V.

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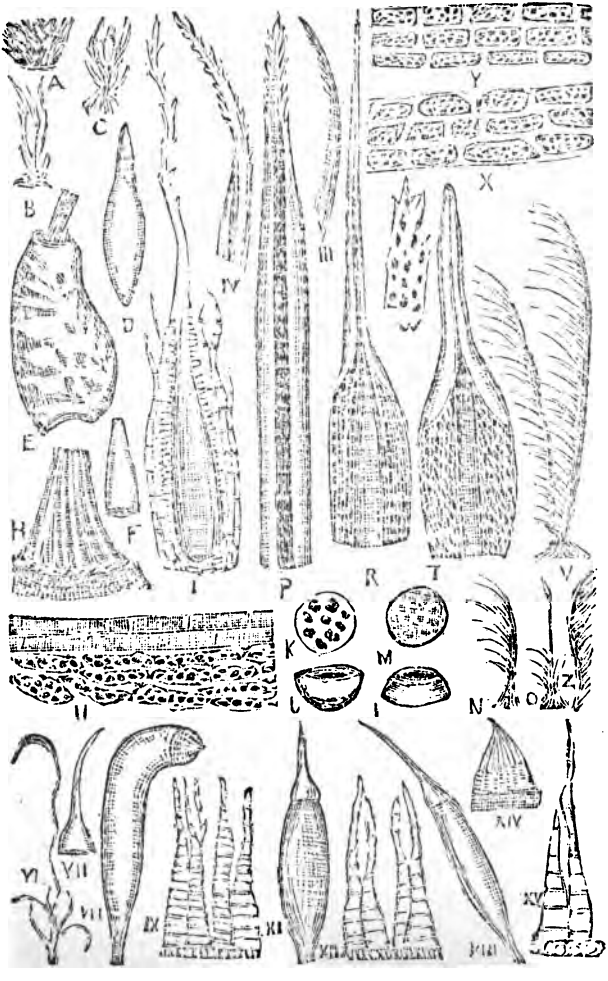
PLATE V.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LESSON VI.

THE APPLE, WHITE, AND VELVET MOSSES.

The Apple Moss, Bartramia pomiformis.

One of the most beautiful mosses which we have in New England may be found on low, perpendicular banks on the shady sides of roads. It is of a pleasant, yellowish-green and grows in thick mats, the basal portions of which are reddish- or yellowish-brown. The leaves are very abundant and slender. When wet they stand upright, but when very dry show an inclination to curl, thus giving the surface of the moss a peculiar wooly appearance. They are serrate for a little more than a quarter of their terminal length, and are remarkable for their inturned or revolute

margins. The costa is narrow, extends nearly the entire length of the leaf, and is inclined to be double, see Plate VI, L.

The growing capsules form one of the most attractive features of this fine moss. They are spherical in form, and at that stage being green in color closely resemble tiny apples, see ib., L and D. As they approach maturity they become furrowed, see ib., D, then when fully ripe and dry assume a bent, cylindrical form wholly different from the young stage, see ib., X, and are brown in color.

The operculum is flat, see ib., C. Peristome teeth are pyramidal in form, are crossed by narrowly separated articulations, and connected together by a segmented membrane, see ib., Y.

The spores are brown in color, and much roughened by minute protubernaces, and thus

somewhat resemble the pollen grains of some of the composite plants, see ib., W.

The facts in regard to this species to be emphasized and reasoned about are; the slender leaves with their revolute margins which serve a double purpose, in assisting to support the leaf, and in a measure to retain the moisture on the surface, while the curling of the leaves is probably due to these margins; the furrowing and shrinking of the capsules assists in expelling the spores, which are retained until a favorable time for distribution by the membrane-connected teeth; the roughened spores, on account of the protuberances, would more easily secure lodgement on perpendicular banks, thus obtaining undisputed possession of territory not readily accessible to most mosses. The fruit matures in late summer

White Moss, Leucobryum glaucum.

Even the casual observer who is fond of woodland walks will remember noticing mounds of pale green moss which grow in rather moist places. This is the white moss, and the mounds vary in size from two or three inches in diameter by an inch thick to a foot or more in diameter by ten inches and over in thickness. This mound-like appearance is due to the fact that while the moss is constantly growing above it dies below, but on account of the plants being crowded closely together, both the dead and living portion continue to stand upright in the middle but fall a little apart on the outer edges of the mat.

The leaves are of a pointed oval form with the margin of the terminal third inrolled, see ib., P. The cells are rhomboidal, and when highly magnified will be found to have the central portion empty when dry, but filled with

water when the leaf is wet, thus the chlorophyllose portion is confined to the margins. The walls of the hollow portionare supported by hoop-like fibres by which they are kept apart and water is admitted into them through pores on their surface, see ib., M.

Although this moss is abundant it fruits less often than most species. and usually much more commonly after a wet summer.

The bent capsules ripen in early autumn, and when magnified present one of the most beautiful objects in moss life. The calyptera is nearly white in color and splits along the side thus revealing the chocolate-brown capsule with its reddish-brown operculum against a snowy background, see ib., T.

The peristome teeth are quite similar to those of the broom mosses to which group the white moss is probably not very distantly related.

The facts to be noted are :- the mound-

like habit of growth, enabling a moss with a scanty supply of chlorophyll to subsist partly upon the decaying remains of its own substance and retain moisture; the water absorbing and retaining cellular system, rendered necessary by the small amount of chlorophyll which must be kept active longer in order to supply the needs of the plants; the general form of the leaf and structure of the capsule shows the retention of ancestral characters, because the plant exists under conditions where no change is necessary in these parts, while the peculiar cell structure of the leaf illustrates an instance of the variation of characters along similar lines, shown by another and quite different group, because both forms have similar needs. Thus, while the nearly unchanged structure of the capsule and form of the leaf clearly points to the relationship of this species to the broom mosses, we cannot consider the sphagnum-like leaf cells any

indication of relationship between this moss and the sphagnums.

Fruiting more abundantly after a wet summer would be the result of increased energy due to the prolonged activity of the vegetative powers of the plants induced by an unusual supply of water.

Velvet Moss, Ditrichum tortile.

The mosses that we have hitherto been considering have been quite conspicuous species, possessing characters that rendered their identification comparatively easy, but the species that we are about to study is much smaller hence the identifying characters are much more obscure.

This moss grows on rich, moist soil which has been recently disturbed, and on which general herbage has not had time to grow. It may be recognized by the the short velvet-like leaves, and abundant yellowish-brow

capsules which stand erect and have short-beaked operculums, see cut on page 14.

The leaves are rather broad at the base but narrow to a slender point on the upper third and are slightly serrate at the tip, and the costa is very stout, but does not quite reach the tip of the leaf, see ib., A. The cells are closely packed, of varying sizes, and irregularly rhomboidal in form, see ib., B.

The capsule is cylindrical and somewhat swollen in the middle. The calyptera is large and split on one side much as in the white moss, see ib., U and cut on page 14.

Operculum of Ditrichum tortile.

Removing the short beaked operculum (see margin) we find directly beneath it a ring of scale-like organisms that surround the peristome, see ib., E. This is the annulus and its function is to assist in throwing off the operculum. This is the first point to be emphasized in our study of this species.

The peristome teeth are sixteen in num-

ber and while in general form they suggest those of the broom mosses in their terminal division, it will be seen that the teeth are, as a rule, cleft nearly to the base, and although there are two divisions in most of these teeth a great deal of variation will be found in them; in some cases one division may be much shortened or even wholly wanting, see ib., V.

This condition of the teeth will suggest that one of two things are occurring; a partly developed tooth is becoming more highly specialized, or a retrogradation is taking place, and the teeth are gradually shortening. To settle this point we will turn back to our past studies and see if we can find any facts that will aid us. In Lesson III we found that the hair-caps, although specialized along certain lines, probably still retain a primitive form of teeth, and these are single with no indication of being cleft., hence we may safely conclude that a cleft tooth has been derived

from one that was more simple. From this we may reason that a developing tooth would be simple and uncleft.

The teeth of the velvet moss are not only cleft but deeply cleft, hence we may conclude that they are deteriorating. Why is this occurring? Now, as we are all aware, in the study of nature matters are constantly arising which we do not understand, and about which it is very easy to ask questions that may be exceedingly difficult to answer.

But all problems, no matter how difficult they appear, are open to investigation, let us see, then, what we can decide concerning the above question.

The facts we have to guide us are as follows:- The moss grows quickly before the newly disturbed soil on which it is found becomes covered with other vegetation; the leaves are small, but the capsules are abund-

ant, and in all cases turn eagerly toward the maximum light supply; they remain green until a short time before maturing, which occurs in early autumn.

Now, although these facts may count for much in aiding us at arriving at a conclusion, we should early learn that any one series of facts may not be wholly adequate to enable us to establish a definite theory. We must become familiar with other series of facts presented by different forms of animate life that may have a bearing upon the subject in hand before forming a decided opinion.

But every naturalist understands the value of what he terms a working hypothesis, and he may base his opinions for the formation of this upon a single fact, or better, upon an isolated series of facts.

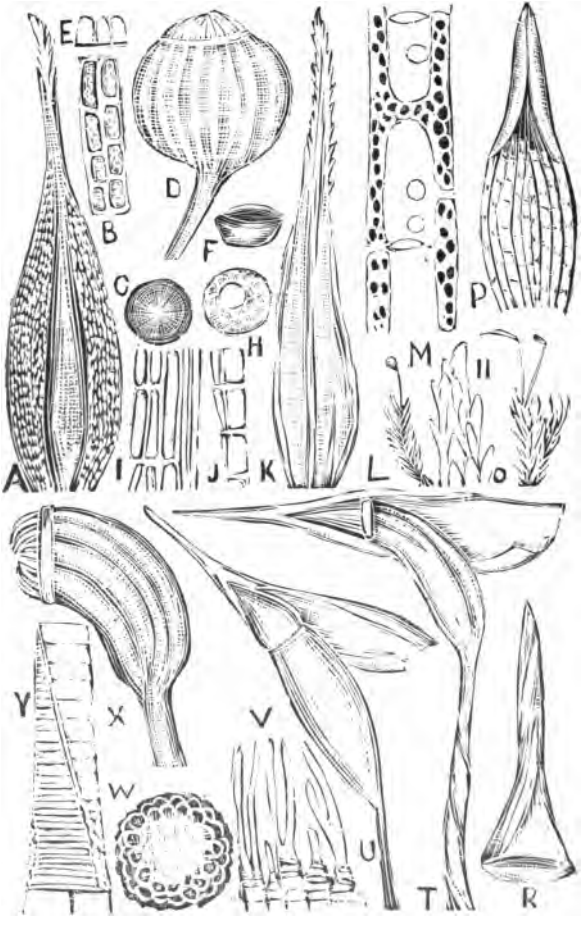
The following, then, we will consider as our working hypothesis in regard to why the

teeth of the velvet moss are deteriorating, then depend upon our future studies to determine its true value.

It would be an advantage for a moss which must grow quickly to develop its capsules without first producing a crop of large leaves. On the other hand, these capsules could not be developed without more nutriment than the scanty leaf supply could furnish them. Hence other methods of obtaining food supply through some extended cholorophyllose surface would be forthcoming.

This in the present species is to be found in the capsules themselves. They are endowed with the power of assimilating nutrition, hence the reason why they seek the light so eagerly. Because they do seek the light the capsules have acquired the habit of remaining upright and long teeth would be disadvantageous to capslues that remained upright when endeavoring to discharge their spores,

and for this reason the teeth of the velvet moss are being curtailed.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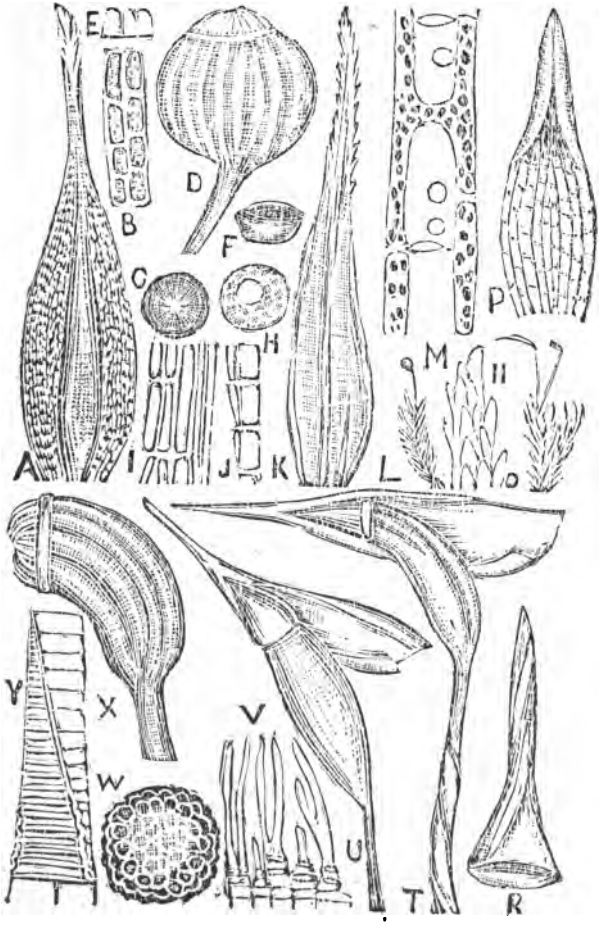

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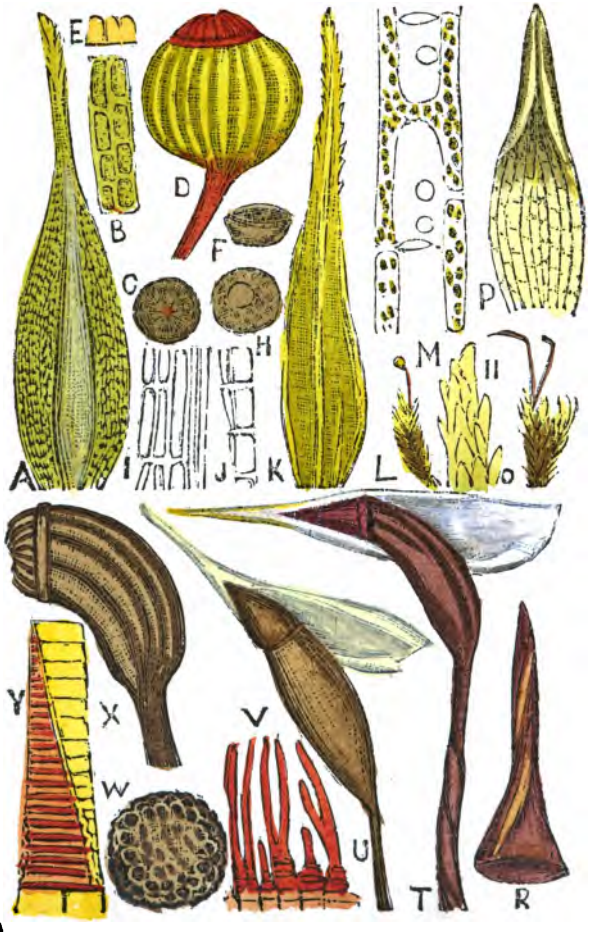


EXPLANATION OF PLATE VI.

Bartramia pomiformis :- L. plant, 1 ; II, tip of leaf, 20; K , leaf, 10; I, leaf cells; J, marginal cells, both 100; C, operculum, 10; D, capsule, green; X, same dry, both 20; Y, tooth, 100; W, spore, 500.

Leucobryum glaucum :- O, plant, 1; P, leaf, 10; M, leaf cells. 100; T, capsule, 20; R, operculum, 25.

Ditrichum tortile :- A, leaf, 10; B, leaf cells, 100; E, scales of annulus, 20; F, spore dry; H, same wet, both, 100; U, capsule, 20; V, teeth, 50.

Ditrichum tortile, much enlarged.

LESSON VII.

THE LITTLE BROOM MOSS. THE PURPLE MOSS. THE SWAMP MOSS.

The Little Broom Moss, Dicranella heteromalla.

This moss may be found growing on shaded roadsides or in open woodlands, but usually in rather poor, dry soil. Although to a casual observer it somewhat resembles the velvet moss, it may be recognized by the secund leaves which are much like those of the regular broom mosses, (see Plate VII, L) and the long beaked operculum, see ib., P. This character can readily be seen with the unaided eye by holding the moss against the light.

It will not require much labor for one at all practiced in moss study to see that the supposed resemblances between this species

and the velvet moss are due to very superficial characters, like small size, fine leaves, and erect capsules.

We cannot observe the species long without seeing that its true relationship is with the broom mosses, for it has ths same leaf growth, similar leaf cells, see ib., K, and similar capsules, see ib. O. The teeth are also not dissimilar, see ib., R, but these are of irregular sizes, and recall those of the velvet moss, and like those of that species, appear to be deteriorating, possibly from a similar cause.

Noting its general resemblance to the broom mosses, then taking into consideration its small size and irregular teeth it would appear as if it were a degenerate form derived from this genus (Dicranum), which had become dwarfed by growing on poor, dry soil.

The Purple Moss, Ceratodon purpureus.

This is another species which in its small size and fine leaves bears a superficial resem-

blance to both the velvet and little broom mosses. But the leaves are short pointed and have their margins thickened, see ib., D, and the moss is spread in thin mats on compact soil in open places especially by the sides of beaten paths. Then the capsules which mature in early summer are deep reddish-brown, and although erect when young become bent and deeply furrowed upon maturing, see margin and ib., V. The operculum, although sharp at its termination, see margin, is without a beak.

The teeth of this moss are double, being cleft nearly to the base, see ib., Y, are of regular form, bright ruby red in color, and margined with orange colored segments, see ib., X. They form beautiful microscopic objects.

Owing to its habit of growing on compact, dry soil, the purple moss must hasten the ripening of its spores while it is supplied with the abundant moisture of spring. It then re-

Capsules and operculum of Ceratodon purpureus.

mains more or less quiescent during the dry months, but renews its vegetative growth in autumn, thus acquiring energy to put forth its capsules in spring.

A moss growing in the comparatively barren places where this occurs would be likely to possess strong, unvarying characters to meet its needs. We find these in the short, strong leaves, in the capsule bent and furrowed for discharging its spores, with well developed teeth to regulate their dispersal at the proper time, and the spores are provided with a harder covering than we find on those of most mosses, probably to prevent them from developing until the rains of autumn come to favor their growth.

Swamp Moss, Aulocomnium palustre.

This moss, as its name would seem to imply, occurs in swampy places. It grows in thick mats which are of a peculiar yellowish-green appearance, and its stem with their

short leaves are of irregular lengths, some projecting much beyond those which form the body of the mat.

The leaves taper gradually to their tips, are finely serrate along their entire margins, and are provided with a very narrow, sinuous costa that does not quite reach the tip of the leaf, see ib., E and H. The leaf cells are irregularly hexagonal in form, with those on the margin more elongated and consequently quite different from those which form the body of the leaf, see ib., F.

The capsules somewhat resemble those of the purple moss, but are longer, not as deep brown in color, and the tip of the operculum is rounded, see ib., W.

The peristome teeth are pale green in color, uncleft and provided with rather numerous articulations. The teeth are accompanied by slender organisms some of which are as long as the teeth and others shorter. These

are known as the segments and cilia, and are probably the result of the degeneration of the epiphragm, their funtion still being to assist the teeth in regulating spore distribution, see ib., N.

Growing among the stems of this moss are long, slender processes, or flagella, see ib., M, the function of which is probably to produce gemmae, which result in a kind of asexual reproduction, to be explained in another lesson.

In the swamp moss we have a species which on account of its habitat receives a plentiful supply of water, hence produces a rather luxuriant growth of vegetation. Yet it does not fruit as abundantly as might be expected, probably because a portion of its energy is expended in reproducing by gemmae.

This lesson has been given mainly to teach the student to avoid superficial characters in his identification of species, for these

are slight resemblances beneath which will be found important differences, that the earnest investigator, who is training himself to look into the heart of matters, will not fail to discover.

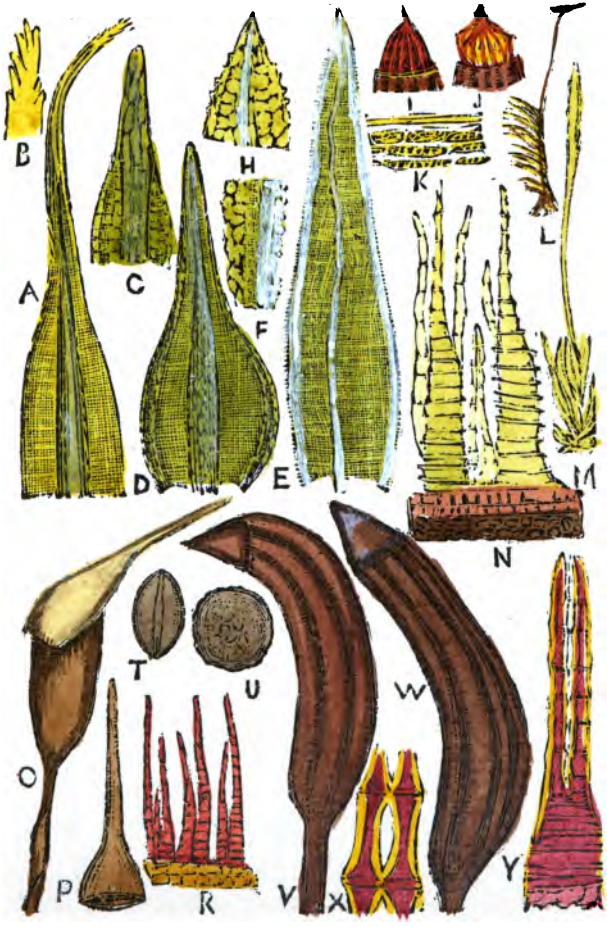
EXPLANATION OF PLATE VII.

Dicranella heteromalla :- A, leaf, 10; B, its tip, 20; L, plant, 1; O, capsule, 10; P, operculum, 10; R, teeth, 500; K, leaf cells, 500; I, peristome, 10.

Ceratodon purpureus :- D, leaf, 10; C, its tip, 20; J, peristome, 10; Y, teeth, 200; X, portion of same, 400; V, capsule, 10; T, spore, dry; U, same wet, both 500.

Aulacomnium palustre :- E, leaf, 10; H, its tip, 20; F, marginal leaf cells, 20; N, teeth, 200; W, capsule, 10; M, flagella, 10.

PLATE VII



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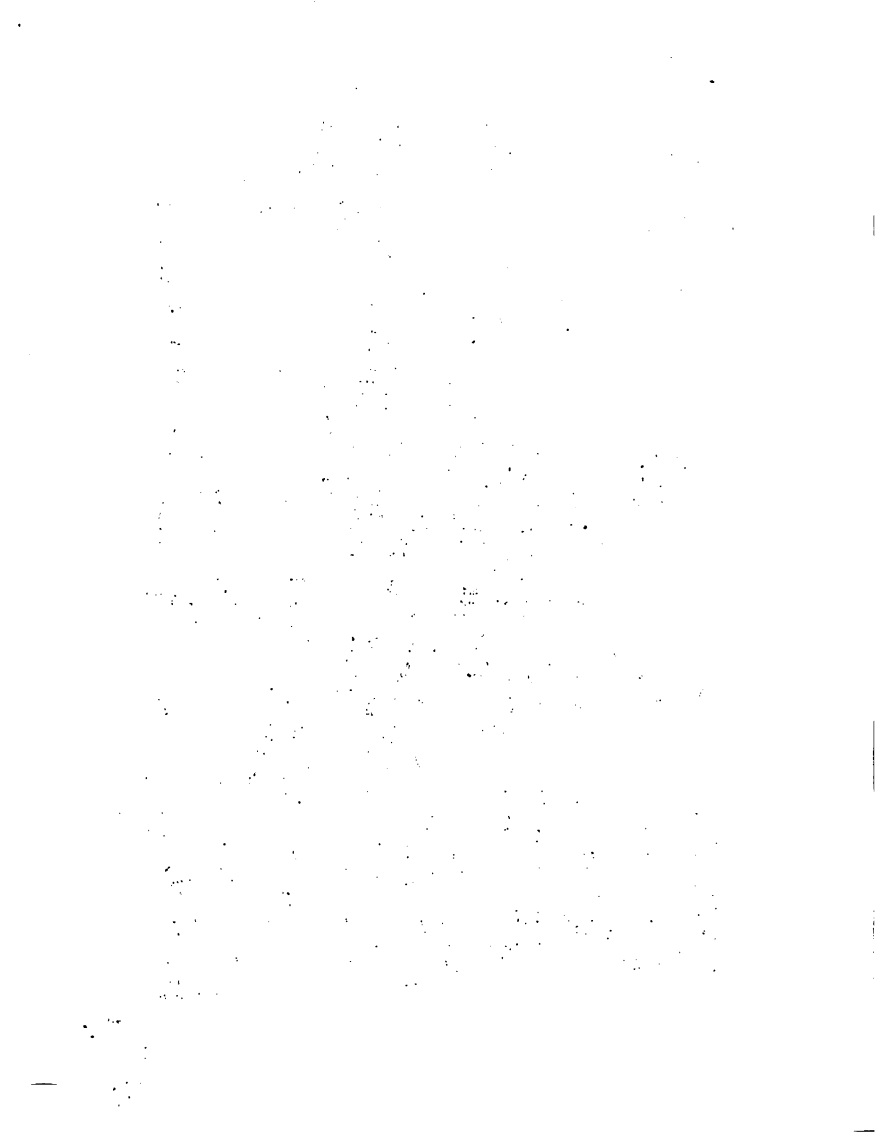
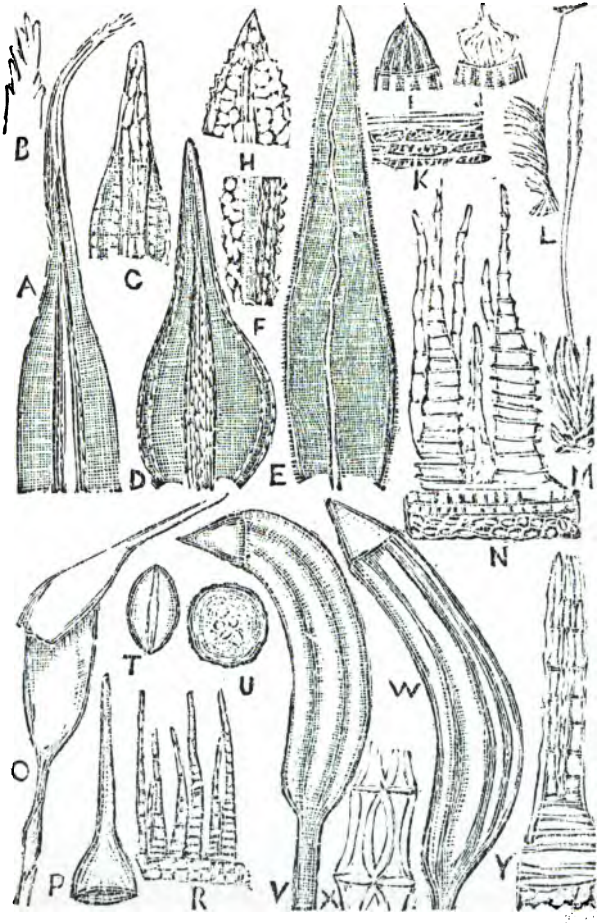


PLATE VII



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LESSON VIII.

THE CUP MOSS. THE WINGED MOSS. THE ELF MOSS.

The Cup Moss, Georgia pellucida.

If we search in swampy woodlands, we may find a peculiar moss growing on partly decayed stumps or logs. Its color is a lively green, and its stems, which are provided with tiny, oval leaves, stand upright even when dry. The leaves clasp the stem closely but at the termination of many of the stems they are modified into bracts which are so arranged as to form cups, see Plate VIII, B. Within these cups, as may readily be seen by magnifying them even slightly, are a number of round, green bodies, known as gemmae, see

ib., F. These fall out of the cups, probably during damp weather, and by first producing protonema, much as in spores, reproduce the moss plant. I may here remark that there is another class of similar bodies, greatly varying in form and in the methods by which they are produced in different mosses, which differ from the above described in producing a moss plant without the intervention of protonema, these are by some authors considered as the true gemmae and what I have called gemmae are called brood bodies.

The cup moss may be further known by the fact that the capsules, which are quite tiny; have four peristome teeth only, this being the minimum number known in any moss provided with teeth, see ib., W and X. Each tooth when highly magnified will be found to be made up of bundles of fibres that become slightly separated at the tips, see ib., II and Y.

The perichaetial leaves are longer than those on the cup bearing stems with very narrow costa, see ib., A and G. The leaf cells are small and of rather irregular form, see ib., C.

In the cup moss we find a species which on account of expending its energy in an asexual method of reproduction, is rather sparingly provided with small, probably degenerate capsules. Their upright habit of growth and and small number of teeth are correlated and may be explained by reasons given in previous lessons.

The Winged Moss, Fissidens adiantoides.

This is a bright green moss that may be sought after in damp places by streams. The arrangement of the leaves on their stems suggests some of the liverworts, but they differ from that class of plants as well as those of other mosses in having a wing or lamella projecting out from the back of the leaf, see ib., H.

In the mosses which we have studied we have always found that the capsule was developed from the termination of the stem. Such mosses are called acrocarpal. We have now come to a moss, however, in which the capsule grows from the base of the stem, see ib., K. Mosses so characterized are called pleurocarpal.

The capsule of the winged moss is dark brown in color, rather short and thick in form, with its operculum provided with a long, thin beak, see ib., U. The peristome teeth are not unlike those of the broom mosses, see ib., T.

The winged moss has perhaps been derived from the broom mosses and has, through growing in a moist places, had its leaves modfied into a form that is best fitted to assimilate a greater amount of food supply to meet the needs of the increased vegetation of the plant.

The Elf Moss, Buxbaumia aphylla.

The student who in his search for mosses always expects to find some indication of green leaves, however small, will consider this species as quite unique, for he will be unable to detect even a vestige of a leaf about the base of the singular capsule of the elf moss, at least when this is fully developed. I shall make no attempt to describe the peculiar flattened, one-sided capsules of this moss but will refer the pupil to the cuts given, see ib., N, IV, V, and VI. They are of a shinning, greenish-brown in color, and although like nothing else that grows, may possibly suggest some kind of seeds perched on stems. Dr. Grout thinks that they look like "bugs on sticks", but Mrs. Britton rather more fancifully calls them "hump-backed elves", and this has suggested the common name that I have given to the species.

The elf moss grows on sloping land in woodlands where but little other vegetation occurs. Although the capsules sometimes grow close together, they are more often considerably scattered.

A section through the capsule shows that there are two distinct walls, or two capsules one contained within the other and separated by an empty space, see ib., M, but both capsules are connected by numerous filaments that are chlorophyllose, see ib, R and L. As the spores ripen in early spring this sectional arrangement is probably to protect the spores in winter by keeping the inner capsule from coming in contact with the snow.

If we examine a portion of the outer wall of the capsule with the compound microscope under high power we shall find it made up of four or five sided cells of rather irregular form. Among these cells will occasionally be found sunken places. These are the stomata, or

breathing pores of the capsule, and are homologous with similar organisms in higher plants, see ib., III. It is important for us to remember that this particular species of elf moss has the stomata sunken and within one cell, for there is another species, the dwarf elf moss, (B indusiata) that is smaller in size and has the stomata not sunken and made up of two cells.

There are some interesting problems presented by the elf moss which are, with our present knowledge of the species, somewhat difficult to solve.

One of these is whether this is an example of a primitive type and thus possibly developing, or whether it is a species which for some reason has lost its leaves and hence is retrograding. The former opinion is the one which is held by many bryologists, but Dr. Grout thinks that the latter is the more correct view of the case. While in the begin-

ning I must confess that I have not studied the species with as much care as I could wish, but what observations I have made upon it leads me to side with Dr. Grout.

It may be well to suggest that there may be another view taken of this case which is, that this species is the incipient progenitor of a new group of plants derived from mosses.

Another question which must arise with everyone who is familiar with the moss, is whether it is wholly saprophytic, that is, does it acquire all of its nourishment, or at least a greater part of it, from decaying vegetable matter? While its lack of leaves and dull color might suggest this, much remains to be proven regarding this question.

Then in regard to its method of discharging its spores, more study of this problem would not be amiss. In short I believe that the true life history of this exceedingly interesting moss remains to be written.

Points in this lesson to be emphasized are; asexual reproduction by special organisms, resulting in the degeneration of the capsules as seen in the cup moss; the difference between acrocarpal and pleurocarpal methods of reproducing capsules, illustrated by the winged moss and other mosses studied; the modification of the leaves to meet the needs of the plant, as also found in the winged moss; saprophytic habits of a moss, enabling it to produce fruit without either leaves or protonema, as seen in the elf moss.

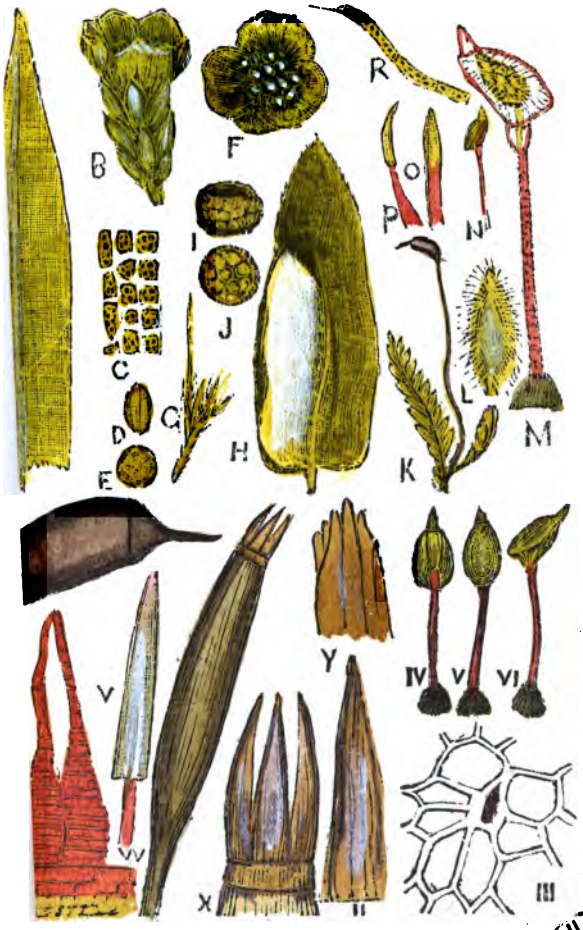
EXPLANATI[illegible]

Georgia pellucida :- A, [illegible]
F, same from above, both [illegible]
E, same wet, both 500: G. [illegible]
growing calyptera, 20; W, [illegible]
tooth, 40; Y, tip of same, [illegible]

Fissidens adiantoides :- H
dry; J, same wet, both 500; K

Buxbaumia aphylla :- N [illegible]
capsule, 10; M, section thro[illegible]
containing spores, 20; R, fi[illegible]
100; IV, back, V, front and [illegible]
capsule and stoma of capsule, [illegible]

LATE VIII.



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EXPLANATION OF PLATE VIII.

Georgia pellucida :- A, leaf cell, 10; B, gmmae bearing cup; F, same from above, both 10; C, leaf cells, 500; D, spores dry; E, same wet, both 500: G, plant with growing capsule, 1; V, growing calyptera, 20; W, capsule. 10; X, peristome, 20; II, tooth, 40; Y, tip of same, 100.

Fissidens adiantoides :- H, leai. 10; K, plant, 2; I, spore, dry; J, same wet, both 500; U, capsule 10; T, teeth, 20.

Buxbaumia aphylla :- N, capsule, 1; P and O, growing capsule, 10; M, section through capsule, 10; L, inner capsule containing spores, 20; R, filament connecting the two capsules, 100; IV, back, V, front and VI side of capsule, 3; III, cells of capsule and stoma of capsule, 500.

PLATE VIII.

PLATE VIII.

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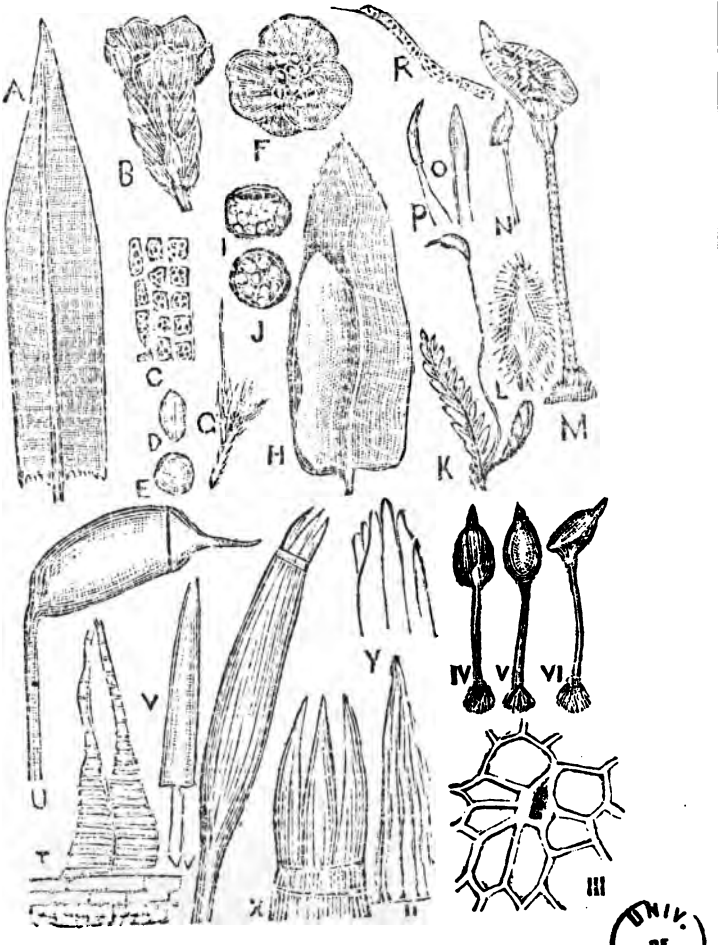
PLATE VIII.



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LESSON IX.

THE MAT MOSS. THE WOOD MOSS THE SILVERY MOSS.

The Mat Moss, Hypnum haldanianum.

Nature ever hastens to harmonize incongruities of color in her domains and to cover unsightly decay with verdure; thus the glaring whiteness of the newly cleft limestone rock or of the lately shivered tree is soon toned down to a pleasing gray; the ivy and woodbine cling to the dead oak and clothe its naked gauntness with living green, and when the same tree falls to earth the humble mosses assist to heap a mound of soil upon it and keep its memory green for many years.

While all who possess cultivated aesthetical faculties enjoy this harmony of color re-

gardless of its cause, it becomes no less pleasing to the student who is accustomed to looking beneath the surface to learn that the gray of the rock and of the broken tree is due to the wonderful affinity which oxygen has for carbon and other elements, or that the woodbine and ivy have simply taken advantage of the support which the naked branches of the oak afford in order to raise their fruit into the sunlight, while the mosses are only appropriating the protoplasm now useless to the fallen tree for themselves. In other words, this harmony in color in nature overlies a harmony of cyclic change; death and decay being but the necessary prelude to rejuvenescence.

This rejuvenescence of the decaying tree often takes the form of the beautiful mat moss, in fact, there is scarcely an old log in the woodlands of this section which does not have one of these mossy mats spread upon it. In color this moss varies from a bright green to

a darker shade, on one hand, or on the other to a yellowish or brownish shade, depending on the light supply.

The mat moss does not always grow on decaying wood but frequently on the base of a living tree or even on damp, compact soil. The size of the mats vary from a few inches in diameter to a foot or more, and are usually of irregular form. The mats are thin and their surface presents a rather ragged appearance, due to the irregular growth and branching of the stems, see Plate IX, A. The stems with their leaf growth are slightly flattened, and wet or dry the leaves do not clasp the stems very closely, see ib., B.

The leaves are of a truncated oval form, see ib., C, and have the cells of the alar or lower angles different from the others both in color and in form. The capsules spring from the base of the stems, see margin, hence the moss is pleurocarpal.

Hypnum haldanianum.

The mat-like method of growth, creeping stems, and differentiated alar cells are generic characters possessed by a large group of closely allied mosses, that require careful microscopic examination to identify. It will be best for the student to learn all of the characters of one species like that of the present thoroughly then he will have a standard for comparison.

The following are the specific characters of the mat moss to be observed. Bright green color, rather inclined to yellowish than to dark green, irregular surface of mats, irregular pinnation of branches, broad-based, rather oval leaves which are abruptly acuminate and without serrations or costa, and which have the alar cells large and brownish yellow in color.

The capsules are cylindrical, brown in color, with the operculum having a beak of medium length, see ib., N. The peristome

teeth are solid, that is, without cleft of line in the middle, but the segments are somewhat cleft, see ib., O, the cilia are very short or absent.

The Wood Moss, Mnium sylvaticum.

Growing in damp woodlands often by brooksides we may find a conspicuous long-stemmed moss of a bright green color. This is the wood moss. The leaves stand well out from the stem when wet but are much crisped when dry, see margin. The leaves are rather oval in form, sharply serrated all around, with a narrow costa which extends beyond the tip of the leaf, forming what is known as a mucronate point, and such a costa is called excurrent; see ib., I. The cells are large and those in the body of the leaf are hexagonal, see ib., F, but those on the margin are quite different, being elongated, see ib., L and K. The chlorophyll grains in all of the cells are large but not abundant and

Mnium sylvaticum.

offer a fine opportunity for investigation, see ib., F and H.

The capsules are large, yellowish-brown in color, (especially when dry) and pendant, see ib., P. The peristome teeth are solid, but the segments are peculiar, being attached together before the opecrculum falls off, but being perforated on either side when torn apart along the perforations, leave projections on either side much as seen on postage stamps; the cilia are well developed, see ib., R. These peculiar segments probably represent an epiphragm that is, on account of the pendant capsule, less differentiated than in many mosses.

The Silvery Moss, Bryum argenteum.

This moss, although a beautiful species, is less conspicuous than many mosses. It grows on dry soil with somewhat creeping stems that send up numerous catkin-like branchlets, the leaves of which are closely clasping

and of a silvery or hoary appearance, see margin. The silvery appearance of the leaves is due to the fact that the upper or exposed portion is destitute of chlorophyll, see ib., J. The leaf is oval with a prolonged point while the rather short, stout costa does not extend more than half way down the length of the leaf. See ib., H. The form of this leaf with its lack of chlorophyll at the termination may be accounted for by the application of the same reasons we used in accounting for the dwarfed leaves in the awned hair cap.

Bryum argenteum.

The capsule is pendant and constricted below the middle, ib., V. The peristome teeth are lined centrally and with the upper third much narrowed and both this and the upper portion of the partly cleft segment are provided with minute projections or serrations, see ib., T.

The present lesson teaches the pupil to observe minute points with care, in order to

distinguish small differences in a genus where there are many species which are often very similar. For this purpose we have become familiar with the mat moss. The genus to which this belongs (Hypnum) is probably an example of a group of mosses in which species are being evolved quite readily when placed under slightly different environment. In the wood moss we have an example of the slow differentiation of the epiphragm on account of the pendant growth of the capsule. The peculiar marginal cells assist in supporting a broad thin leaf. In the silvery moss and awned hair cap we have examples of two species assuming similar characters under similar conditions.

PLATE IX

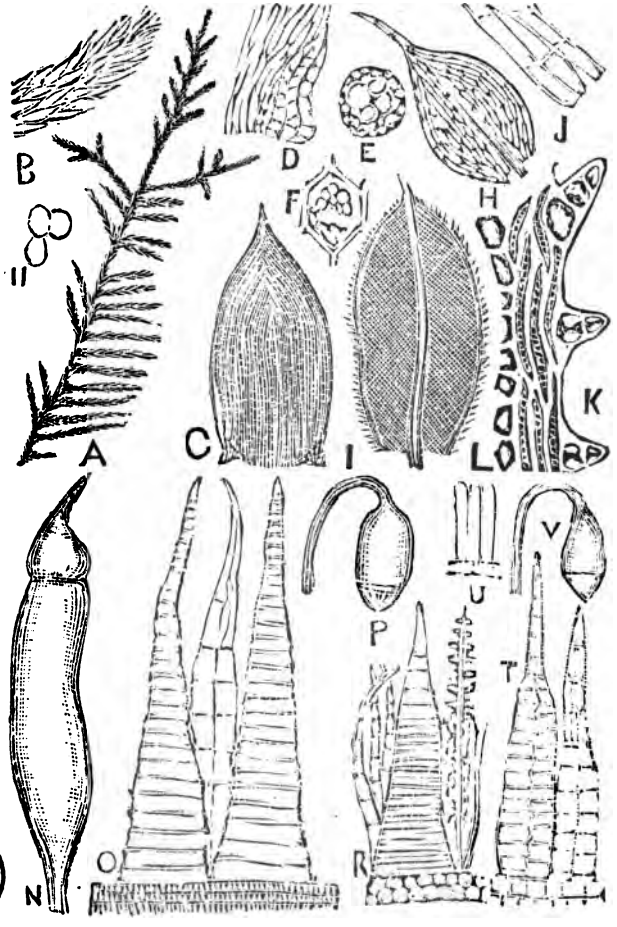

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PLATE IX

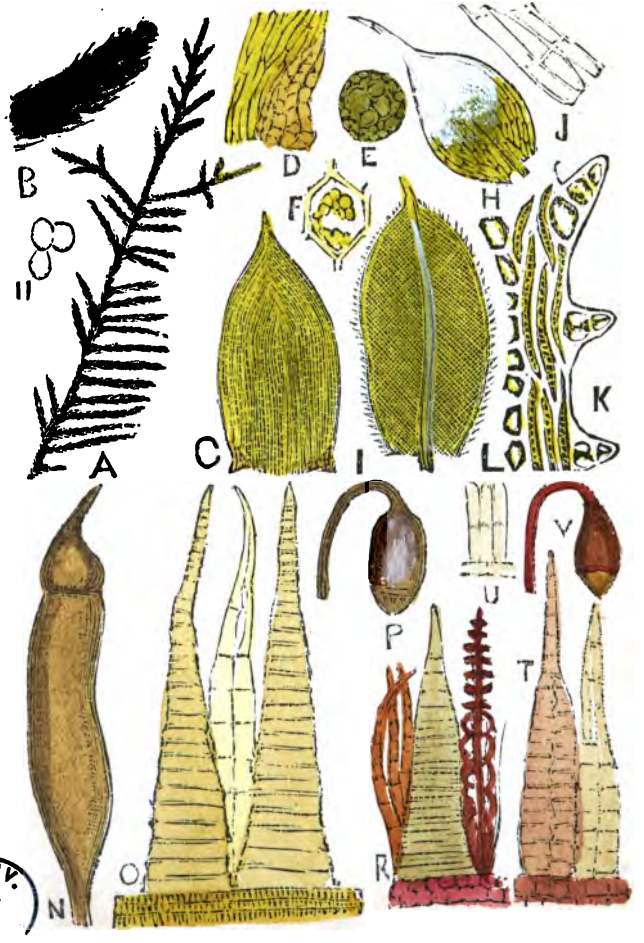

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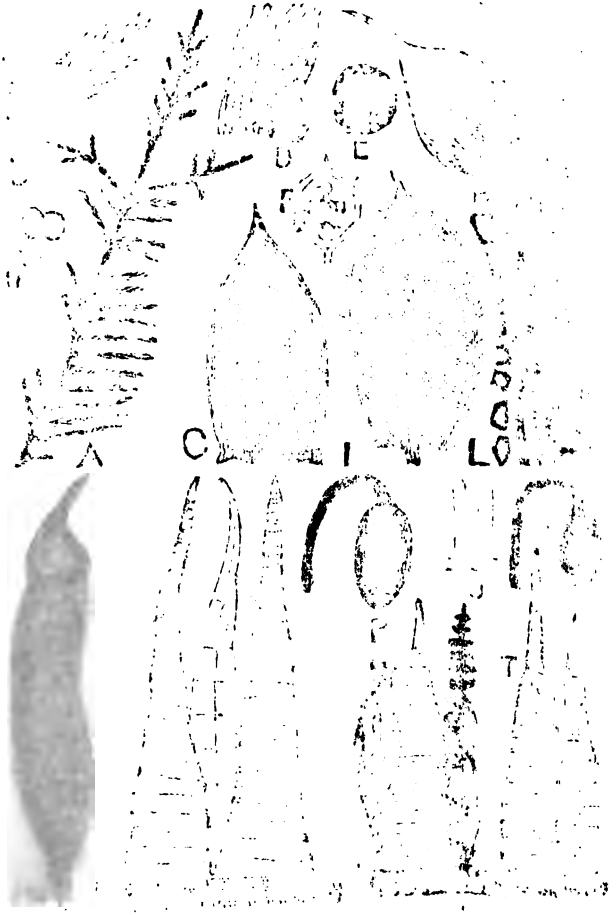
PLATE IX



EXPLANATION OF PLATE IX.

Hypnum haldanianum :- A, plant, 1; B, portion of same, 10; C, leaf ,10; D, alar cells, 50; E, spore, 500; N, capsule, 10; O, peristome teeth, 200.

Bryum argentium :- H, leaf, 10; J, leaf cells, 20; P, capsule, 10; T, peristome teeth, 200; U, annulus, 20.

Mnium sylvaticum :- I, leaf, 10; L, K, marginal portion of same, 100; F, single cell, 500; II, chlorophyll grains, 1000; V, capsule, 10; R, peristome teeth, 200.

LESSON X.

THE SHORT ROCK MOSS. THE YELLOW-GREEN TREE MOSS. THE BLUE-GREEN TREE MOSS.

The Short Rock Moss, Grimmia apocarpa.

If we search on shaded rocks, especially in woodlands, we shall probably find a blackish-green moss growing in more or less loose tufts. The best character by which this species can be recognized is the small, nearly concealed (immersed) capsules which have reddish-orange operculums, see Plate X, A, and which may be seen peering out from among the dusky leaves, see ib., B. This is the first example we have seen of capsules of this kind and they somewhat resemble acorns with the cups growing on top.

The calyptera is peculiar, being cup-shaped and split several times on all sides, see ib., M, and is known as a mitriform calyptera.

The leaves are provided with a thickened margin, hence although somewhat contorted when dry are not crisped. The costa is rather stout and extends nearly to the tip of the leaf, hence is nearly percurrent, see ib., C.

The peristome teeth of all the specimens that I have examined have been short, imperfectly and irregularly developed at the tip and pierced with holes, see ib., N. They are deep orange red or nearly crimson in color. This moss matures its fruit in this portion of Massachusetts in early spring.

The Yellow-green Tree Moss, Thelia hirtella.

Growing on tree trunks among other mosses we shall find a species which is of a yellowish-green color, forming rather loose irregular mats. It is a pleurocarpal moss and consequently its stems are creeping. The

branchlets that stand upright, and are of rather irregular lengths, are not very regularly formed, see ib., O. The leaves are round with an abruptly acuminate tip, see ib., D, while their margins are provided with rather short, slightly curved projections that also occur all over the back of the leaves, see ib., D and E.

The peristome teeth are long, slender, and solid, green in color, and crossed on the lower two thirds by narrow, partly concealed articulations; the segments are short. The capsule is cylindrical, but rather enlarged at the base. This moss matures its fruit in early autumn.

The above is an example of a positive description of a moss, that is it is a statement of facts in regard to the characters as they appear, without comparing them with those of other mosses.

The Blue-green Tree moss, Thelia asperella.

Growing also on trees, but largely on white oaks will be found another moss closely resembling the above described. It differs in being bluish-green in color instead of yellowish. The branchlets are of more regular lengths, hence the surface of the moss has a more level or uniform appearance, and they are much more regularly formed, see ib., L and VI. In general form the leaves of both species are alike but in the present the filaments on the margin are longer and inclined to be forked, see ib.. I, while those on the back are decidedly Y-shaped and not simple and curved, see ib., F.

The peristome teeth are rather longer than in the last, but instead of having slightly developed, nearly concealed articulations these are very prominent and ladder shaped, see ib., H; the segments are short as in the other species.

The capsules are cylindrical, but instead of being enlarged at the base are of about the same diameter for the greater part of their length. This moss also matures its fruit in early autumn.

The above is an example of a comparative method of description and its advantage over the positive method will be appreciated by any one who is trying to identify a moss which he does not know. Botanists have long been accustomed to writing much condensed, positive descriptions, but while such may be well understood by the practiced student, they are often quite unintelligible to the beginner, of whose needs the scientific author is too often oblivious. A carefully and accurately written description of a plant or animal is no less scientific because it is couched in simple language, hence intelligible alike to student and expert, than one that is expressed in long technical terms, which are often understood only by specialists.

The scientist who is a born teacher, and the born teacher whether he is a scientist or not, always possesses the faculty of presenting his subjects to his pupils in a simple, intelligible manner, and when technicalities are necessary he makes them clear by explanations.

Under such a teacher the student of nature early learns to trace resemblances that he may distinguish differences and when he has acquired this power he is in a fair way to become a successful scientist so far as presenting his subjects in a comprehensible manner is concerned, for, as we learned long ago, resemblances mark the higher groups narrowing down to genera, but differences begin with species and narrow backward through the higher groups.

This lesson has been given to illustrate the following points:-

A species of moss that has accustomed itself to grow on rocks where it must remain

dry for a longer portion of the time than many other mosses that grow in other places; such mosses respond quickly to moisture, hence the leaves are kept spread; the short stemmed capsule prevents the spores from being distributed far, hence they would not be likely to be wasted by falling off the rocks on which they best grow, thus we should expect to find this moss on rocks which occur close together and not on isolated ones. The imperfect peristome teeth are again correlated with the upright habit of growth. The two species of Thelia show how necessary close microscopic examination is in the study of mosses if one is to become familiar with the nicer points of difference and we also learn that two closely allied species do sometimes occur under exactly the same environment, for these two mosses often grow on the same tree not infrequently mixed together in the same mat. Perhaps the most plausible ex-

planation that we can give for this is to suppose that both species are the offspring of some common ancestor and that they became evolved into distinct species through living under different conditions but afterwards both learned to live together each keeping its own peculiar structure.

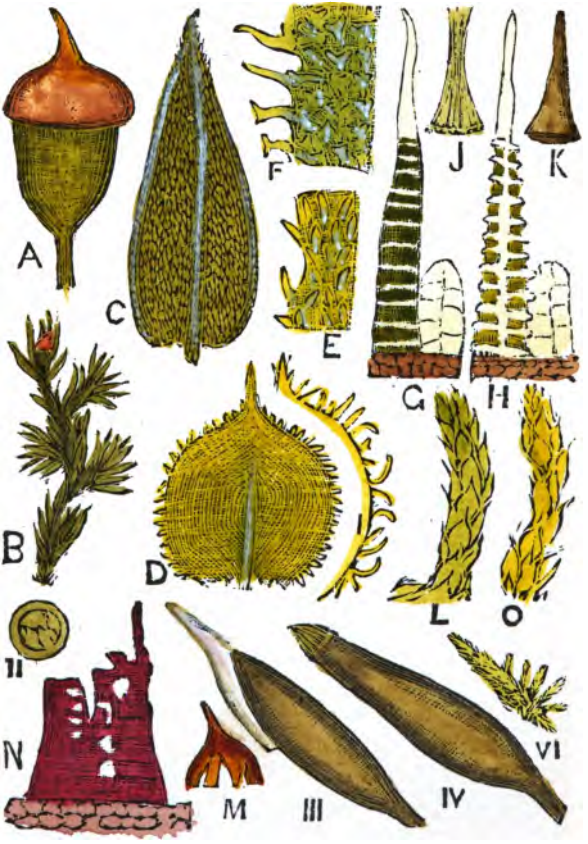
EXPLANATION OF PLATE X.

Grimmia apocarpa :- A, capsule, 10; B, plant, 4; C, leaf, 10; N, teeth; M, calyptera, 5.

Thelia hirtella :- D, leaf. 10; E, portion of margin of leaf, 100; H, peristome tooth, 200; O, branchlet, 10; VI, plant, 1; IV, capsule, 10; II, spore, 1000.

Thelia asperella :- I, margin of leaf, 10; F, portion of same, 100; K, operculum, 10; H, tooth, 200; J, peristome, 10; L, branchlet, 10; III, capsule, 10.

PLATE X.



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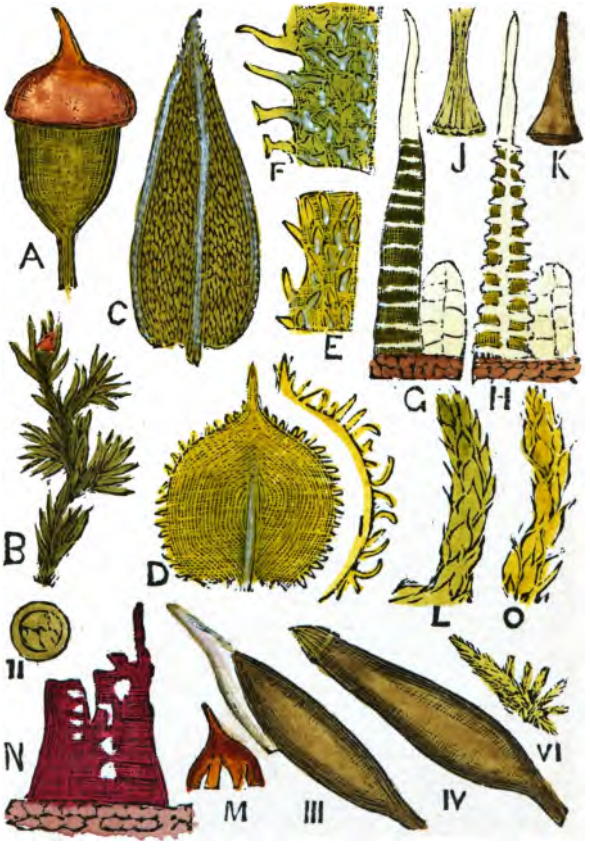

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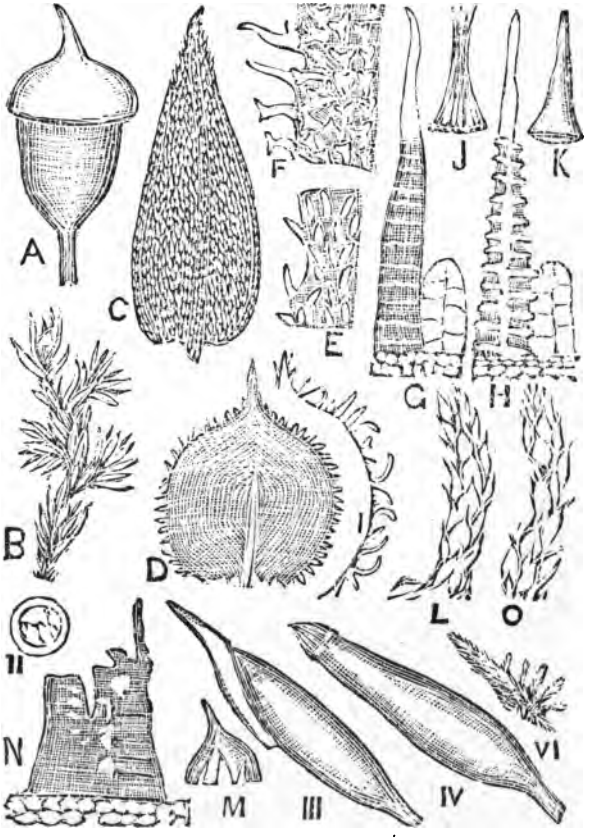

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LESSON XI.

THE DECEPTIVE MOSS. THE PEAR MOSS.

The Deceptive Moss, Entodon seductrix.

Growing on decaying logs in moist places will be found a pleurocarpal moss which somewhat resembles the yellow-green moss for it is about the same shade of color. But it differs from this species in general habit of growth and instead of occurring in extended mats as in that species it is confined to smaller tuft-like patches.

A close examination will show that the branchlets are catkin-like with the leaves closely clasping whether they are wet or dry, see Plate XI, A. The leaves themselves are short oval in form, rather obtusely pointed

and are often provided with short double costa, see ib, B. The leaf cells are of two kinds; those which make up the body of the leaf, which are long, slender and curved in different directions at either end, with the chlorophyll cells very minute, see ib., B, and those in the alar angles which are nearly square, arranged in regular rows, and provided with minute projections along their margins.

The capsules are small, cylindrical, and in general form somewhat resemble those of the blue-green moss, see ib., H, but the operculum is constricted nearer the base, hence does not taper as gradually, see ib., I.

But it is to the peculiar peristome that It wish to call especial attention as we have never seen any thing exactly like it in our studies. The teeth themselves are rather singular being rather less regular in form than those of what appear to be allied species of mosses; they also differ from the majority of peristome

teeth in being composed of sections which are divided in the center, while they are provided with a margin which extends all around, their chief peculiarity, however, lies in the fact that they have their origin below the outer wall of the capsule which projects up in front of them for nearly a third of their entire length, thus they have the appearance of looking over a wall, see ib. D and E.

Such a peculiar arrangement of teeth, and in fact, the teeth themselves would suggest that the teeth of this species as well as those of others in all members of this genus are really segments doing duty for teeth. This matter could be probably settled by a careful study of the growing capsule which can be made by anyone who will exercise a little patience.

The Pear Moss, Leptobryum pyriforme.

A very pretty moss may often be found on sandy shaded, ground but more especially

on ashes in woodlands. It is bright green in color, inclined to be yellowish. The long, narrow leaves stand erect when wet but when dry assume a woolly appearance.

But it is due to the long stemmed, yellowish red, pear shaped, capsules that this moss may be at once recognized. These capsules are pendent and provided with an operculum which has a short rounded knob instead of a beak, see ib., J. This kind of operculum is called mammilar, and this or other short-beaked kinds are often correlated with pendent capsules. The peristome teeth are slender, of regular form, and solid, but are provided with articulations. Like the teeth of most pendent capsules they are supplemented by appendages which alternate with them, see ib., M.

This species is one of the best I know in which to find the annulus; the scales of this being large, and in specimens not too mature, show a central nucleus of chlorophyll, see ib., K.

Much of the long, slender appearance of the leaves is due to the fact that the terminal half is greatly narrowed. The most remarkable thing about these leaves is the wide, thick costa that extends the entire length of the leaf, and it is due to this that the leaves stand upright when dry. This costa is chlorophyllose and thus aids in furnishing nutrition for the plant. This is necessary as the narrow leaf margin on either side of it would not be sufficient to meet the needs of such an abundantly fruiting moss as is this species, see ib., L. The true leaf cells are rhomboidal in shape, see ib., O, and, in fact, not especially well furnished with chlorophyll, hence after all, the plant must depend almost wholly on the costa for food supply.

It is worthy of note that both this species and the cord moss grow best on ashes, but always, I think on wood ashes, or that of other vegetable matter, and that both produce an

abundant crop of fruit. This fruit is provided with long stems in both species. Now while these long stems may be necessary to raise the strongest capsules above the crowded mass where they will receive the most sunlight, in order to produce these long stems the plants must possess superfluous energy. As they do possess this energy it is reasonable to suppose that some element in wood ashes supplies them with abundant food. Knowing as we do, that potash is one of the abundant constituents of this ashes, and that this is one of the great sources of food supply for plants, we can reason that potash then, is probably the food which mosses that grow on ashes are seeking. This leads us to think of the source of supply from which the higher plants originally derive their potash. This our studies in mineralogy will at once inform us is orthoclase or feldspar.

Now reasoning backward a little, is it not probable that such mosses as grow on rocks always select those rocks which are composed in part at least of feldspar, in other words the granitic or even diabasic rocks? Certainly here opens a new, and probably unknown field of observation for the moss student.

In the present lesson we have in the deceptive moss and its generic relatives, found peristome teeth that may have been evolved along different lines than those of most mosses. In the pear moss we have found a general downward growth of the pendent capsule, a mamillate capsule. A peculiar leaf costa, and a most interesting problem in regard to moss nutrition.

EXPLANATION OF PLATE XL

Dicranum scoparium:- A, branchlet, 4; B, leaf, 10; C, [illegible] of same, 25; D, peristome teeth from inside, 100; E, [illegible] outside; F, leaf cells, 200; H, capsule, 10; I, operculum, 20.

Leptobryum pyriforme:- J, capsule, 10; K, section of capsule, 2; L, leaf, 10; M, peristome teeth, 200; N, plant, 3; O, marginal leaf cells, 1000; P, spore, 1000.

PLATE XI.

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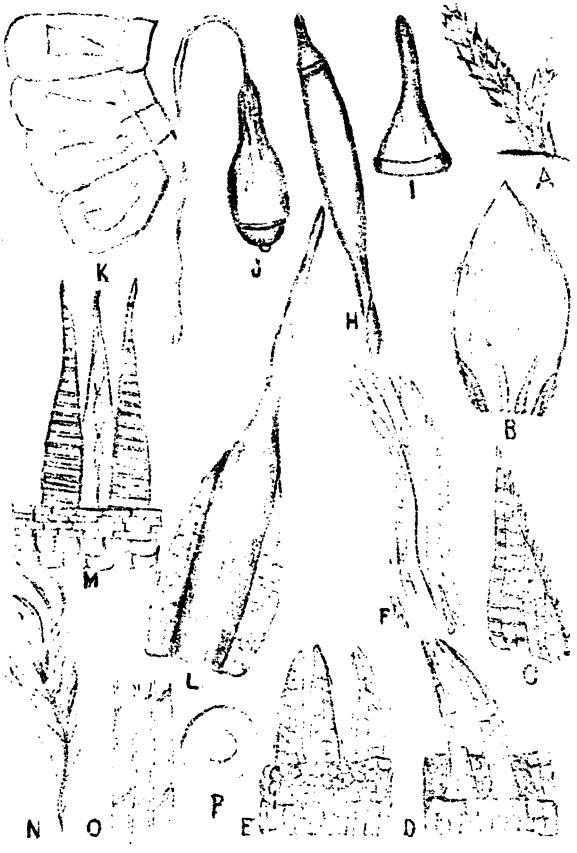
PLATE XI.



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LESSON XII.

THE HAIR MOSS. THE FEATHER MOSS.

The Hair Moss, Dichelyma capillaceum.

Although some of the mosses that we have already studied have grown in damp places, none have actually lived under water, unless they have been temporarily submerged by occasional inundations. The present species, however, forms one of a group of mosses that pass all, or at least a greater portion, of their lives under water.

Sometimes the hair moss may be found in shallow pools but it grows more commonly in hillside streams that are usually dry during the warmer summer months, a fact that it will be well to remember in studying its structure.

One of the first things that we shall observe about this moss is its habit of growing in mat-like masses which somewhat resemble tufts of hair, whence both the specific and common name. In color it is dusky green much brighter at the secund tips which in form recall the broom mosses, see Plate XII, A. It can readily be seen that this mat-like habit of growth would be beneficial to the moss in assisting to retain moisture longer when the streams became dry.

The calyptera of this moss appears to be be shed early, hence is difficult to find.

[NOTE:- The word which I have written calyptera, is sometimes spelled calypter but more usually and more correctly calyptra.]

This moss fruits abundantly and the capsules will be found growing on the extreme tips of specialized branchlets, see ib., B On account of this peculiar method of fruiting there appears to be some disagreement among

authors as to what position in the systematic arrangement the group to which this species belongs should be placed. On account of the specialized lateral branchlets it does not exactly belong with the acrocarpal mosses which have the fruit wholly terminal, and unless we consider the whole branchlet as a part of the fruit it does not belong with the pleurocarpal mosses, although some modern authors have placed it there. It seems perfectly reasonable and exactly in line with our studies in the evolution of forms to regard the aquatic mosses that produce their fruit on lateral branches as an intermediate between the acrocarpal and pleurocapal mosses, thus scarcely belonging to either group, hence it seems as if it would be of assistance to the student if they were placed in a group by themselves as has been done by no less authority than Lesquereux and James in their Manual of the Mosses of North America, and call them, as they have done, cladocarpal mosses.

The peristome of the hair moss is peculiar and its peculiarities are shared to a greater or less extent by all of the cladocarpal mosses. The teeth are long and linear and often adhere together, but are of irregular lengths and inclined to be imperfect. They also appear to be shed very early, see ib., F. On the other hand the inner peristome is well developed and provided with segments, or (as Lesquereux and James consider them) cilia, which are longer than the teeth and which are connected together by transverse projections at the top thus forming a partly latticed cage, see ib., D and C, which must have considerable influence upon spore distribution, in other words the inner peristome has been specialized to meet the needs of aquatic mosses.

The capsule is thin, its walls being only one cell thick and affords an excellent opportunity for study, see ib., E. The leaf cells are long and slender with exceedingly minute

chlorophyll grains. This moss fruits in late summer.

The Feather Moss, Neckera pennata.

Growing on the trunks of trees, especially in mountainous regions will be found this beautiful moss. It is of a pale yellowish green color and although a creeping species, the new shoots stand out from the main stems and thus at right angles to the tree, when their pinnate forms and closely crowded, but laterally growing leaves, produce a feathery effect that is very attractive, see ib., I.

The leaves are thin, rather irregularly oval in form and slightly serrate at tip, see ib., L, and without costa (ecostate). The leaf cells are rhomboidal in form at the base; above this they are long, slender, and provided with minute chlorophyll grains, see ib., M.

The capsules are partly immersed among the leaves. They are green when young but become yellow with age and finally brown,

while the operculum is always bright orange, see ib., J. thus they are easily seen and add much to the beauty of the moss. The peristome teeth are small, slender, and pale yellow in color. They are divided into sections which are redivided in the center by an often poorly defined line. The teeth are often attached together at their tips. The inner peristome is absent or merely shows rudimentary segments.

The specimen figured and described was collected by Mr. H. C. Dunham at Moosehead Lake, Maine on September 25, 1904, and kindly given to me by Mrs. Dunham. It contains both empty and green capsules, which are however, nearly fully grown. By this we may judge that the fruit ripens in summer.

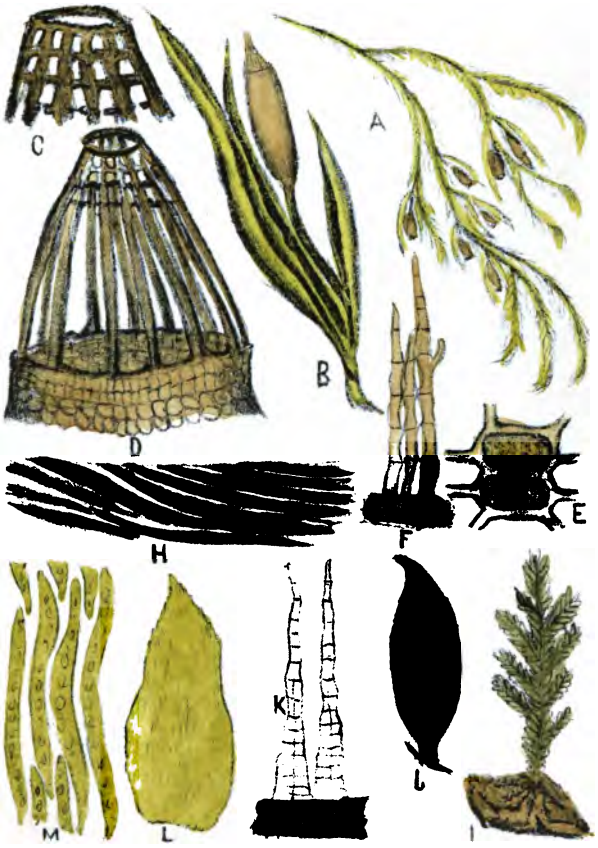
In this lesson we have become acquainted with an aquatic species of moss and have found that the organisms have been changed to meet the environment, that is if we believe that

EXPLANATION OF PLATE XII.

Dichelyma capillaceum :- A, plant, 1; B, capsule, 10; D, inner peristome, 100; C, top of same, 200; F, teeth, 200; E, cells of capsule, 1000; H, leaf cells, 1000.

Neckera pennata :- I, plant, 1; J, capsule, 10; K, peristome teeth, 500; L, leaf, 10; M, leaf cells, 500.

PLATE XII.



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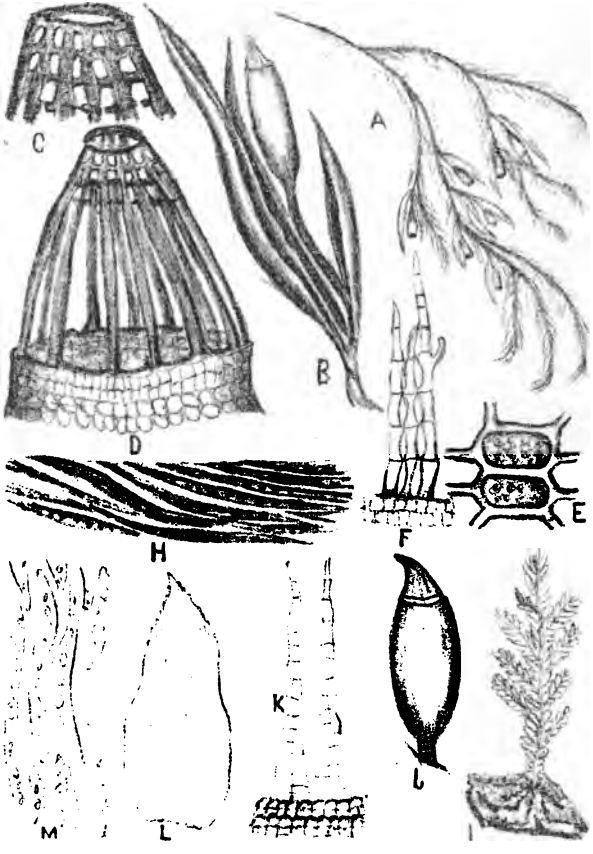

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mosses as such first became evolved on the land and afterwards some became changed in order that they might live in water. Of course this change was brought about very gradually probably through the immersion of some land moss for a portion of the year, the time of immersion slowly increasing while the organs of the moss changed to meet the new conditions under which it had to live.

Our studies in the evolution of mosses have taught us two things; one is that evolution does not always mean advancement but sometimes a species saves its specific life by becoming dwarfed, as in some of the rock growing mosses; another is that although one organism may be more highly specialized as the moss advanced along some particular line, some other portion of the same species may become greatly deteriorated. This is illustrated in the hair moss, where the inner peristome has become developed and the capsule

wall so thin that it is doubtful whether this moss could now perfect its fruit out of water.

In the feather moss we have a species that even in a cold climate can live in an exposed situation like a tree trunk and acquire a luxuriant habit of growth.

THE END.

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